INTER AVIA

Review of World Aviation

In this Issue :

B. J. Hurren : The Price of Air Power

Fire on Board ! — GCA Blind Landing System

Sovereignty and Civil Aviation — Economic Aspects of Aeronautics

A. von Zeerleder : New Method for Joining Light Metals

The AAF Does All Right

VOLUME II Nº 3 MARCH, 1947

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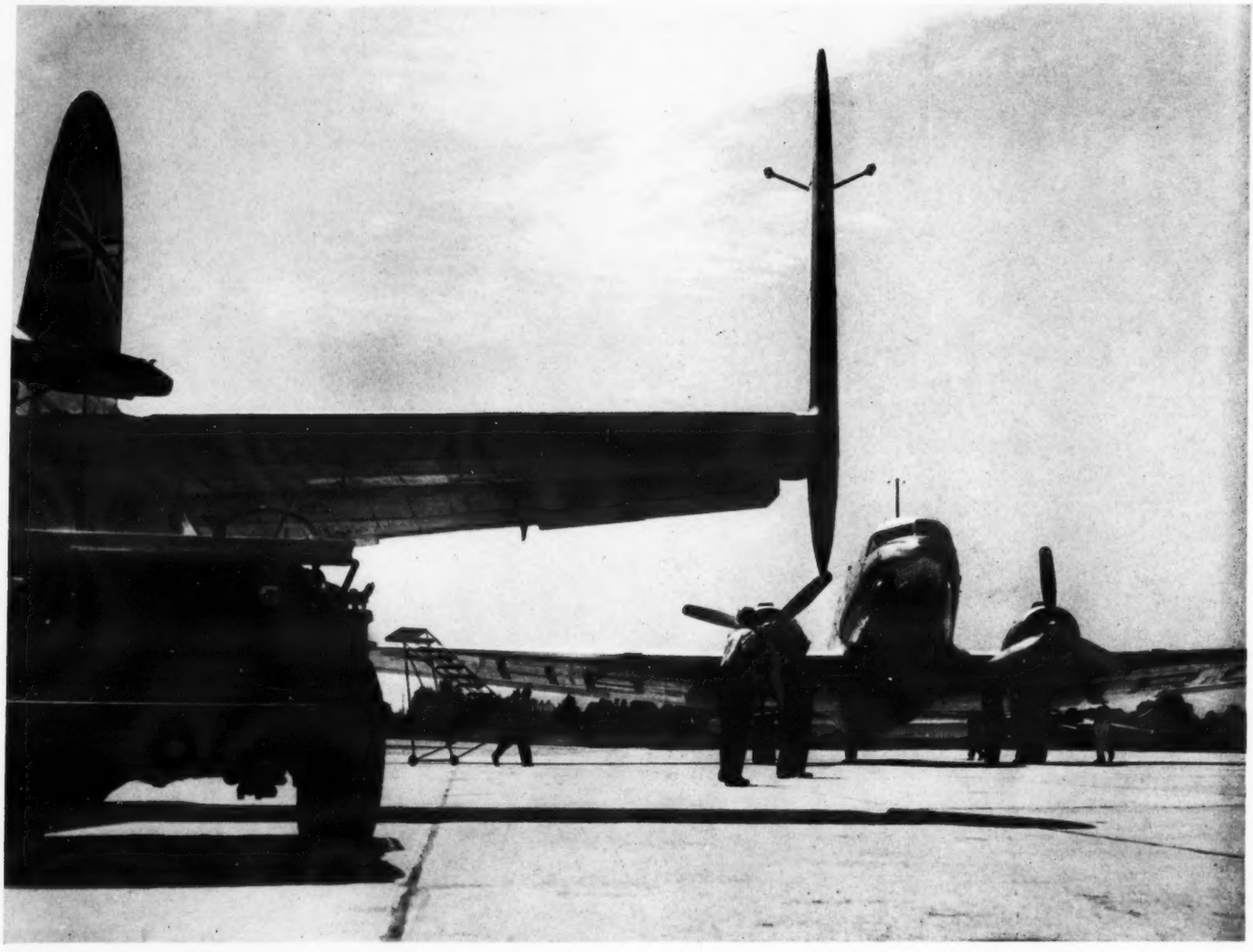

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Review of World Aviation

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Volume II | March, 1947 | No. 3

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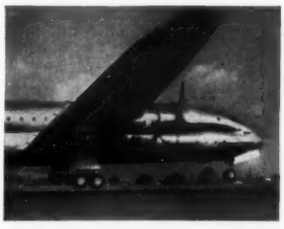

Front Cover :
Lockheed "Constitution" about to touch down.

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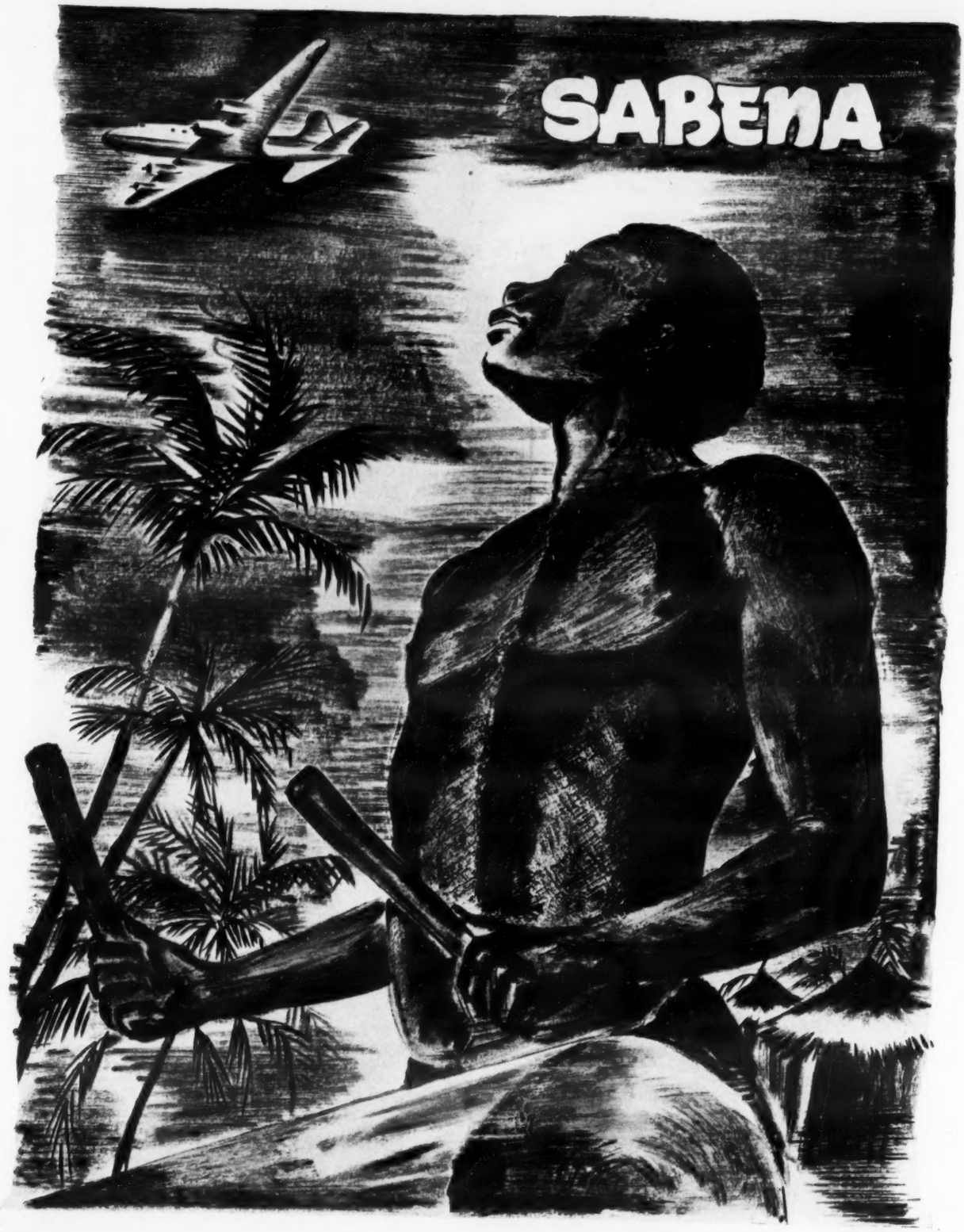

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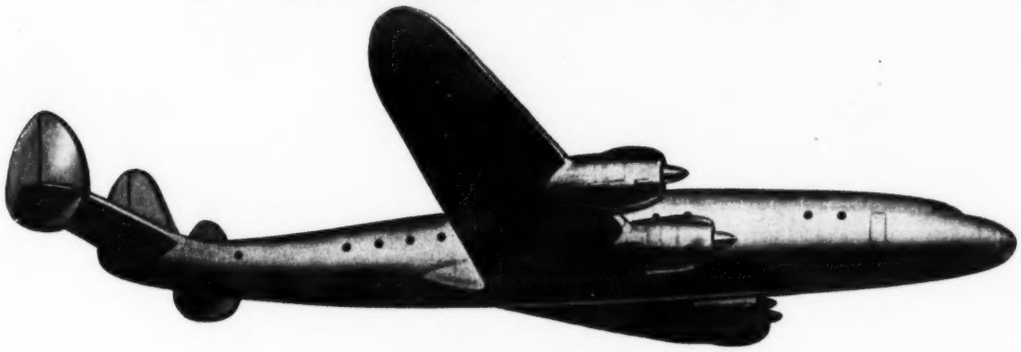

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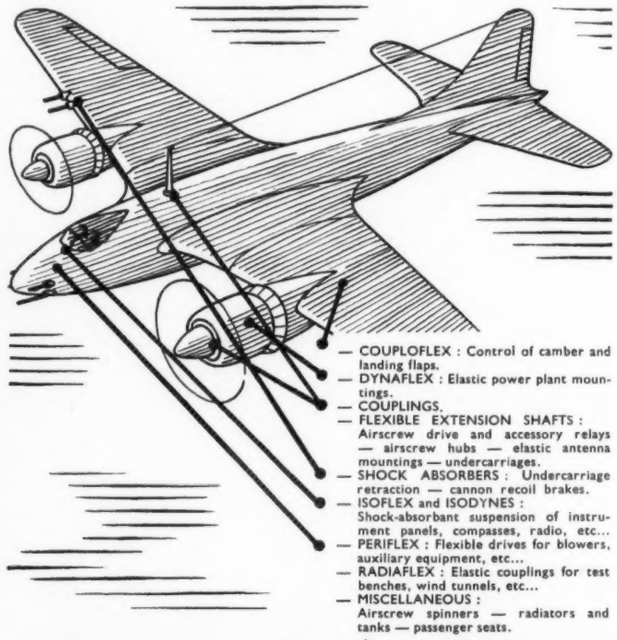

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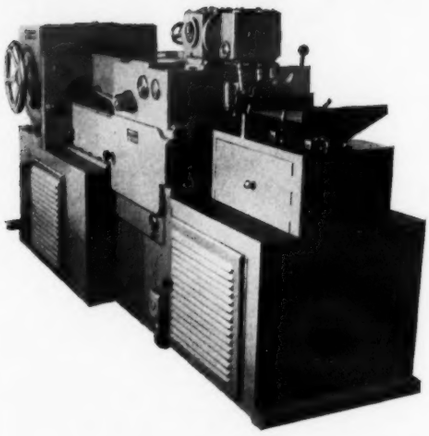

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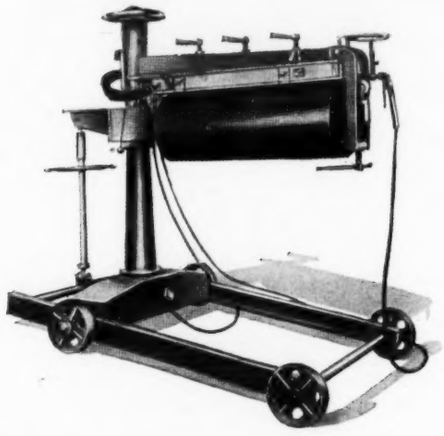

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Marginal Notes

Domestic Animals on the Prop'.

By Michael Sostschenko.

A Russian satire... Perhaps unknown to some...
It is hoped that it will please everyone.

I. The Horse on the Prop'.

Grigorj Kossonossov, a guardsman at the flying school, was going home on leave to his village.

" Listen, comrade Kossonossov, " his pals said as he was leaving, " as you are going home, how about spreading a little propaganda around the village ? You know, tell the good peasants how our aviation is getting on... One can never tell, they might decide to pool something for a plane ! "

" Have no fear, comrades, " Kossonossov answered readily, " there will be propaganda enough. It wouldn't be quite the same if it weren't about aeroplanes. But you know me ! I'll tell them all right ! "

When Kossonossov reached his village he lost no time in calling on the local soviet.

" Look here, " he said, " I've got something big to tell you all. How about a meeting ? "

" After all, why not ? " the chairman replied. " Go right ahead. "

Next day, the peasants held their soviet at the fire station. Grigorj Kossonossov walked out front, bowed, and began :

" Well, it's like this... flying, comrades... well, as you're an ignorant and backward lot, I'd better try to explain it with politics. Over here, let's say, is Germany, and there, perhaps, France... Here Russia and there... Er... Ah... Hm. "

" Whatever *are* you talking about, Grigorj Kossonossov ? " asked the peasants.

" What about ? " retorted Kossonossov indignantly, " Why, about flying, of course ! Big future in aviation, very big ! ... Now, with Russia over here and China... Er... "

The peasants were getting agitated. " Get on with it, " someone shouted impatiently from the back of the shed, " don't waste so much time. "

" I'm not wasting time, " mumbled Kossonossov, who had by now lost a little of his earlier importance. " I'm telling you about aviation... It's growing in Russia, comrades. You can't tell me it isn't. Facts are facts ! "

" Hm ! A little confusing ! " exclaimed the chairman. " Please be more traditional, comrade. Nearer to the people. "

Kossonossov shuffled towards the group of peasants, stretched one leg forwards a little uncertainly, and started off again :

" Well, comrades... We build aeroplanes in Russia, and then fly them. Up in the air, so to speak ! Now, some fellows manage to stay up, some don't, so that... bang ! crash ! down he comes. Like our comrade, pilot Jermilkin. He flew up fine, and then — bang ! crash ! Just a sticky mess left ! "

" Not quite a bird, then, " assented the peasants, nodding wisely.

" That's it, that's what I mean ! " exclaimed Kossonossov, pleased to find someone in agreement. " By no means a bird. A bird, when it falls down, well, Er, it shakes the dust off and — off it goes again ! Men are different. Now, there was another flyer like this. Smack down on a tree. Hung there like an apple. And was he scared, poor chap ?... laughed ourselves sick ! Plenty of things like that ! Even a cow once got caught in the propeller. Snip ! Snap !—chopped it into little bits ! Dogs too... "

" Horses too ? " asked the peasants, anxiously, " horses too, Grigorj Kossonossov ? "

" Horses too ! " he proudly assured them, in deep, condescending tones. " Very often. "

" Ach, scoundrels ! May the Devil take them ! " growled one of the listeners. " What will they think of next ? Chopping horses up ! So, Grigorj Kossonossov, you mean to tell us that all this is growing ? "

" Yes. That's just what I've been trying to tell you all along. It's all very much developed, comrades... That's why I wanted all you peasants to pool the money. "

" What this ? Pool money ? What for ? " asked the peasants with curiosity.

" For an *aeroplane,* of course ! " replied the orator, triumphantly.

The peasants' reply was to grin amazedly, and amble out of the shed.

* * *

Dejected, the good Kossonossov returned to camp, without the money for a new aeroplane. It was unfortunate, but his native villagers were indeed too ignorant and backward !

II. Let's say... the Aviation Journalist on the Prop'.

The case is bad, but asinine reporting doesn't make matters any better. One may well ask, what *haven't* the self-styled air correspondents managed to misrepresent in reporting the last black series of crashes ?

" Why so many fatal accidents ? " asks one of them. We take it that he means serious crashes, or such entailing death tolls. In the last eight weeks " there were fifty aircraft accidents, counting 250

victims killed—tragic and drastic news. " Is it his intention to encourage people ? In his own words : " The risks of travelling by air are not to be ignored. They are, however, small. A plane takes off every second somewhere in the world, which means 86,400 take-offs of passenger and cargo craft each 24 hours. "

The man is an adding machine gone beserk, an aeronautical Münchhausen ! Assuming that each aircraft makes four intermediate landings on its scheduled trip — a high average, anyhow—then this would mean that 17,280 aeroplanes are flying the world's air routes. With the whole of American aviation, the world's largest air line group, possessing only 816 commercial aircraft in February, 1947, it would be optimistic to reckon on even twice this amount for the other countries. Hence, at the most, 2,400, and not 17,280 aircraft !

Of course, it is an easy matter, with 86,400 day and night take-offs—which don't occur—or 17,800 commercial aircraft—which don't exist—to minimise air crashes.

And here is what another one of these experts wrote recently : " X Company is an admirable concern. Its flying equipment is absolutely first class and its pilots are all trained to perfection. The service on board is the acme of politeness, attention and homeliness... There is no doubt that X Company will win not only public sympathy, but also the support of many thousands of passengers... A trans-Atlantic service is soon to be inaugurated with Y-type airliners. "

This highly-lauded air line company—it is just as good as other large concerns, but its minstrels can get on one's nerves a little—has so far had no less crashes than any other carrier. Incidentally the heralded Y-type airliner was officially grounded for trans-Atlantic operations before X could begin these. This rectification was omitted.

Just about the worst mistake one can make is to reckon on the public's lack of memory or the readers' stupidity.

A third reporter comes along with : " Is air travel dangerous ? "

In his final conclusion he says : " Even if all these established shortcomings are not to be rectified immediately and the newspapers repeatedly report air crashes, there is still no reason to avoid travelling by air... "

This gentleman may keep his remarks. Not every air traveller is in such a hurry to commit suicide !

Where does all this empty speech and would-be consolation get us ? After all, does it not boil down to the same sort of propaganda as that made by Grigorj Kossonossov to his native villagers ?

Not only horses can get in the way of the propeller—it sometimes happens to their longer-eared relatives too !

III. Railway Accidents in the Year 1864.

A letter from an anonymous reader :

February 2nd, 1947.

The Editor, Interavia, Geneva.

Sir,

Perhaps you will read with as much interest as I have read your wise commentary on the recent black series of aviation accidents, the attached paragraphs which I am excerpting from an editorial printed in The Illustrated London News *of June 18th, 1864.*

It deals with one of the worst railway catastrophes which up to that date had happened in Great Britain. As you will see, men's attitudes and thoughts are apt to repeat themselves. Just as is the voice of common sense ! Even if sometimes it takes, as in this case, 83 years !

Neither the Egham catastrophe nor the many others which had to come afterwards, have prevented the rail from covering the whole surface of the earth. That very year, 1864, saw the turning of the first turf for the Buenos Aires Great Southern Railway.

Would you care to reproduce this instructing echo of the XIXth Century for the benefit of the readers of Interavia ?

Yours faithfully

J. P.

Interavia's thanks to reader J. P. Here is the excerpt :

" The late collision of trains at Egham... has, naturally enough, excited considerable and very various discussion in the public prints. If we recur to it, it is not with any purpose of recounting its too familiar and shocking details, or of discussing its probable causes, or of pouring abuse upon railway boards, or of suggesting infallible preventives,—but merely, while the subject is fresh in mind, of making a few remarks pertinent to a subject which interests everybody, and designed to lessen, if they cannot prevent, those moral mischiefs which almost invariably follow in the train of a railway calamity...

We venture to suggest that the load chorus of indiscriminate vituperation with which railway directorates are apt to be assailed whenever loss of life occurs on the line... is likely to do harm rather than good. We speak merely as onlookers, without the smallest personal or pecuniary interest in the matter... A fast train may run with marvellous punctuality from London to Edinburgh every day in the year for four of five years without injury to either person or property, and when there is a breakdown, it is too often censured in a strain which implies... a reckless disregard, on the part of the directors, of the lives of those who have relied upon their care... By all means, let blame always fall where blame is deserved ; but if it is to have due weight, credit also must be customarily and ungrudgingly given where credit has been earned.

On the comparative merits of affirmative and negative signals which a collision of trains is sure to bring up fresh for discussion, we shall not presume to give an opinion, which, indeed, would be of no value unless it represented a greater experience in the management of railways than any to which we can lay claim. We confess, we should be loth to stake our lives upon the infallibility of any system in which the agency of man is indispensable. The day may perhaps come when an exclusively self-acting mechanical method of signalling may be discovered and adopted. But, while the world waits... two things are imperatively needed... An adequate staff of servants, so that their physical powers be not broken down by overwork ; ... that it be subject to the strictest discipline. "

That is what *The London Illustrated News* wrote 83 years ago.

That particular journalist hoped for a mechanical method of signalling. Today, he may be protected from rail and air accidents, but his hopes were not in vain.

He called for an adequate staff and strictest discipline. The world's railways have truly fulfilled his demands.

And air transportation ? We desire, we demand, and we hope for... But we ascertain that—just as 83 years ago—precisely those critics are heard most who understand nothing about the subject. We might well conclude that our technically-advanced generation is mentally backward. In any case, that Englishman of 83 years ago had more common sense than many of his later generations, no matter what nationality.

And, with shame, we must recognise that—ourselves included—not one of the present-day aviation journalists has shown such understanding for the recent series of air crashes, as John Bull revealed for the railroad accidents during the reign of Her Majesty Queen Victoria.

EEH.

The Price of Air Power

By J.B. HURREN

On the tarmac a number of sleek-lined high-speed aircraft stand waiting. The casual onlooker observes a pilot come from an office, climb aboard one of the aircraft, and in a few minutes take-off for a half-hour's flight, in which he makes aerobatic manoeuvres over the aerodrome before returning to a safe landing and the re-positioning of his aircraft on the tarmac.

It all looks so easy, for this is the Royal Air Force. After all, that is what aeroplanes are for — to fly. Why, then, make a fuss ?

The simple picture is not artless, but, in fact, exceedingly complicated. It must be linked with the wave of nationalistic feeling which is sweeping the world. The old order has changed, and countries which yesterday were debtors, now find themselves with (on paper) vast credit balances, in particular with Great Britain.

Now, any politician with an eye to fame — that is to say all of them — sees clearly that Air Power is something in which his country must take part. If he cannot have aeroplanes, then he has aerodrome sites, or raw materials for the making of air power. Note that this picture differs entirely from that existing in history up to the middle of the Thirties. Then, power for "power politics" meant primarily a strong Navy and secondly a strong Army. A small and highly race-conscious country like Persia or Egypt had no hope of raising the funds or producing the technical skill to have a Navy, though she could make some move towards an Army for tribal or hill operations. Such moves did not really amount to much in the distribution of world power.

Now the picture is changed. A small country with a highly efficient, albeit small, air force can if expertly used in War possibly become of as much influence as a bigger country. Armed with atom bombs or worse in very limited numbers, such a small country becomes no longer a pawn in world power but, if not a Queen or a Castle, at least a roving Knight capable of wreaking havoc and one to be enlisted For rather than Against.

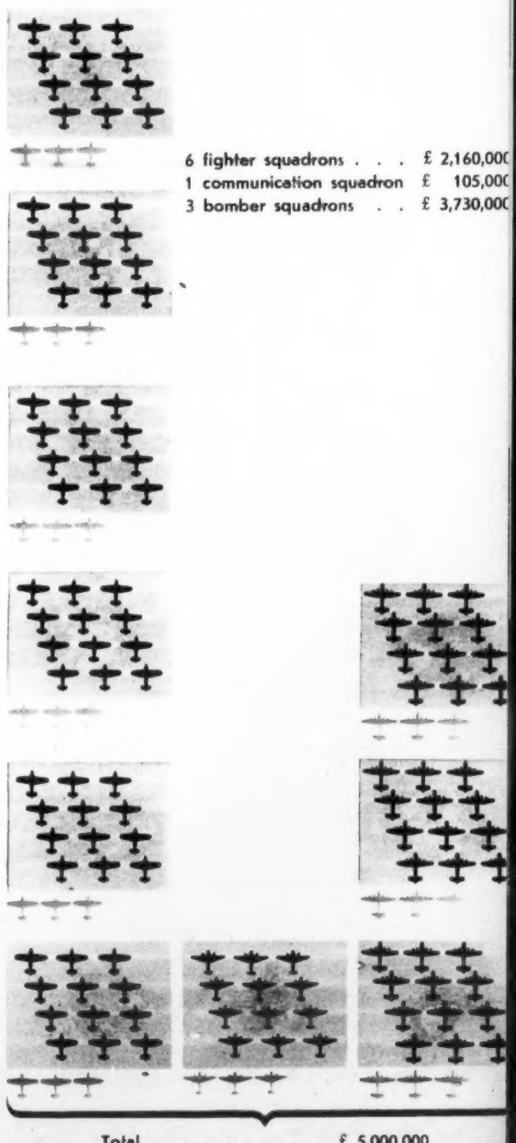
The first step to such a position in world affairs, a step unprecedented in world history since the big battalions no longer matter, is to acquire air power, and to get that it is essential to have an air force.

Now, reverting to our opening picture, the rising politician sees how simply the R. A. F. fly and thinks : " We don't want a lot of aircraft, we want the qualitatively best, so let us purchase ten squadrons of aircraft and find pilots for them and *then* we shall be a power in world councils. "

So, fired with a bright idea, moves are made to get ten squadrons of aircraft — a force of, say, 150 aircraft including immediate reserves. It sounds too easy, until the price of air power is totted up.

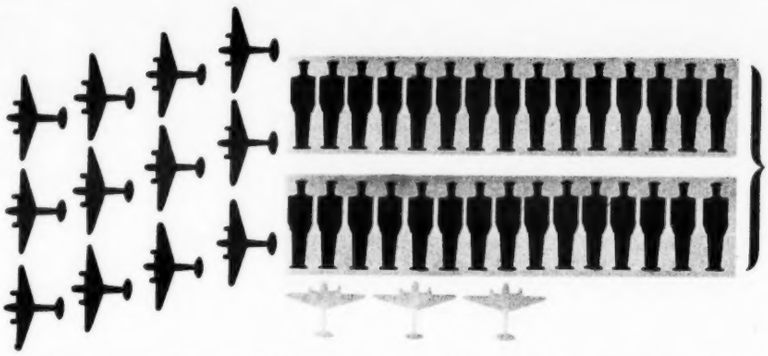
In the first place, modern aircraft are expensive. As a rule of thumb measure (but often wide of the mark) it can be said that today combat aircraft cost around £ 2 per pound weight. This computation varies considerably, for the lighter the aircraft the more it would be influenced by the equipment ; and some radio equipment costs thousands of pounds. Before the War the rough reckoning figure was £ 1 per lb. ; the increase being due to higher wages and materials costs and to immensely increased technical equipment.

Let us imagine the ten squadrons required by Ruritania comprise one communication squadron, six combat (fighter) squadrons, and three bomber-reconnaissance squadrons. Taking 3,500 lbs. for the communication aircraft, the first-cost bill for that one squadron could be £ 105,000. Taking the single-seat fighter as



12,000 lbs., the cost of six squadrons could be estimated at around £ 2,160,000. If we keep the bomber type down to a twin-engined design, the average weight might be about 30,000 lbs. (although many models are more than this), and the cost of three squadrons would run to around £ 2,730,000.

It is emphasized that these are only rough and ready calculations and that in certain categories the figures could be far wrong. However, ignoring subsidies and artificial means of supply whereby, as before the War, foreign governments purchased obsolete R. A. F. equipment for 1/200 th. of its original cost to the British taxpayer, it can be seen that for merely the front-line equipment of a small force of ten squadrons the bill runs to five millions sterling. How inaccurate this figure could be may be gauged from the fact that there are several twin-engined communication aircraft which are three times as expensive as that at present stated. Nevertheless, we can safely say that £ 5,000,000 is not an exaggeration.



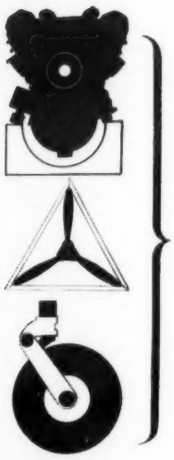
Officers of 10 Squadrons £ 500 each annually £ 250,000

between September, 1939, and June, 1944, and this total included 6,208 naval aircraft, and 25,346 were trainers). In round terms, two fifths of the output concerned fighters and one quarter trainers. So, in order to train the squadrons' flying personnel, we must provide for another quarter in trainer aircraft — and the bill mounts to £ 7,500,000.

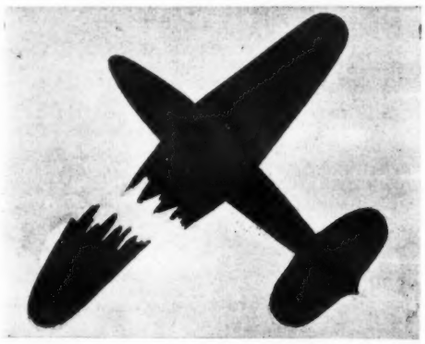
Now, losses in war and accident wastage take a heavy toll. It is said that the R. A. F. in six years of war experienced some 80,000 accidents. American figures showed

primitive — but then air maintenance suffers accordingly. The R. A. F. computed that a new bomber aerodrome amounted to more than £ 1,000,000 and a fighter about £ 850,000. Even the Western Desert aerodromes were not inexpensive affairs, though they were not as great as the R.A.F. in Britain in costs. However, we might fairly say five aerodromes, including one maintenance base, for at least £ 2,000,000.

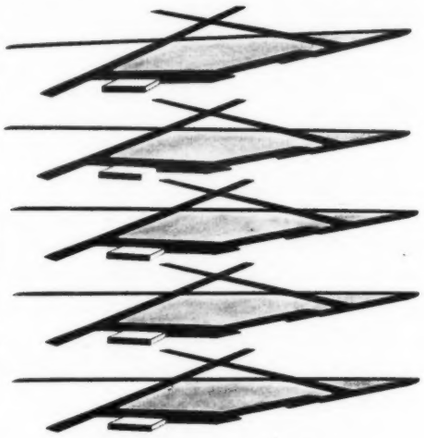
Now, squadrons vary in size—the fighter unit is generally twelve, with three in immediate reserve. Officers or rating pilots are



Spares 20 % . . £ 1,000,000
Total . . . . £ 6,000,000



Deterioration and losses 30 % . . £ 2,500,000
Total . . . . . £ 10,000,000



5 airfields . . £ 2,000,000
Total . . . . £ 12,000,000

We must now take an assessment for spares, which, in the British production programme, ranged from 15 % to 60 % of aircraft numbers. If we take a low average of 20 % we shall not be far wrong, and the bill now mounts to £ 6,000,000.

In the R. A. F., during War, a total of more than 102,000 aircraft was completed (to be exact 102,609 was the grand total of new production

the average "life" of a bomber in war to be ten months, and the average live of a fighter seven months. It would, therefore, be perfectly justifiable on the basis of past figures to compute a wastage and deterioration figure of one third; and our total now tops £ 10,000,000.

Hitherto we have ignored the factor of hangars and airfields. These can be very

needed, and with adjutant, medical officer, intelligence officer, and kindred officers, approximately 30 officers go to a fighter squadron, and 50 to 60 to a bomber. Our ten squadrons could require, in round terms, 250 officers of all categories; to which we must add at least a further 250 in training duties. The higher officers would receive substantial emoluments, and the lower about £ 300. If we take an average of £ 500 a year (including allowances in cash or kind) the ten squadrons in the first line would be needing £ 250,000 a year in salaries alone.

The example need not be continued further. It is clear that even by paring down to lowest costs, a small air force cost milions. A wise chancellor would seek for some £ 15,000,000

Trainers additional 25 % . £ 1,500,000
Total . . . . . £ 7,500,000

in the case cited ; and in doing so he might well pause on the edge of such a financial brink. Reliable figures show that a country grossing 15,000,000 natives has annual budget of about £ 45,000,000 ; a wealthy European state of 4,000,000 people has a budget of £ 16,000,000 ; a South American state of 16,000,000 has a budget of £ 60,000,000. Other examples show an average small state has a budget of £ 3 - £ 4 *per capita,* and a rise of 25 % in the budget to pay for a small air force of doubtful influence in world affairs is something that might cause a boomerang to smite the politician.

It is, however, a picture not quite as gloomy as that. If a small state finds itself either with a near-monopoly of certain raw materials, or in a geographical position of strategic advantage, then much of the training and backing-up work required to build a small air force can be shouldered by benevolent allies. We thus see Portugal, for 500 years an ally of England, retaining her independence and her small defence force by the purchase of the material for a nucleus air force which, it well knows, could be supported by British air power directly in case of war. That, in fact, is what happened in Egypt with the Egyptian Air Force in the last war, and what could happen with other small states in any future war.

For the key to this matter is that although there is a world-wide rise in national consciousness, there is no equivalent rise in technical ability. One man in five, in the world, is a Chinaman — yet China has not even produced a motorcar engine ! About one man in seven is an Indian, yet India, for all its wealth and history, has never shown anything other than an elementary aptitude for mechanical and automatic things. The technical superiority abides in the Western Powers, which are today progressing at such a rate that the wonder of Tomorrow is obsolescent in three or six months. The maintenance of that lead in technicalities is one reason why the price of air power is high, and why it is necessary for the countries of small reserves to rely on the Western Powers where no falling off in the " know-how " of the engineers will be allowed to arise.

Editor's Note : The Author speaks of " Western " and naturally places emphasis on British aircraft and British deliveries. There is no doubt that today the Western Powers, notably the Americans, have the upper hand as regards aircraft deliveries. All the same, one might also mention the " Eastern ", namely Russian deliveries, which were made to Eastern and South Eastern European states.

GCA

Heavy fog and blinding rain had closed the U. S. Army Air Base at Yokata, Japan, to all normal air traffic. The radio station had no option but to divert incoming aircraft to other fields which were still open. The radar crew was standing by as usual in the radar van, scanning the scopes which occasionally revealed aircraft flying the regular air route north and south.

Suddenly the radar controller manning the search scope picked up an aircraft apparently off course, flying to the west of the airfield at fairly low altitude in the direction of high mountains. He immediately began calling " Plane flying 270 degrees heading " on all transmitting wave lengths available in the radar van. For several minutes there was no reply.

Finally the pilot answered : " This is Army 082, flying a 270 degree heading. Do you want us ? "

The radar controller could now speak : " Army 082, this is Yokata GCA. You are heading for high mountains directly ahead. Make immediate 180 degree turn and vector 90 degrees. "

" This is Army 082. Are you sure you mean us ? We are supposed to be still over water... "

The radar controller repeated his message, but this time being more emphatic. And the pilot made a quick turn in the opposite direction. The GCA crew did not relinquish the contact until it had landed the aircraft safely at Yokata. It was a Boeing B-29 and it had missed the mountain by less than a mile — 15 seconds !

In a similar way, scores of other aircraft of the U. S. Army and Navy have been preserved from disaster thanks to the GCA system.

GCA, abbreviation for Ground Controlled Approach, is an instrument landing system for aircraft during periods of absolute minimum visibility. The basic idea is to spot and track an approaching aeroplane with a radar search beam and, by radio-telephony, to give the pilot all the instructions required for a landing.

Already before America's entry into the war the idea was born in the Radiation Laboratory at the Massachusetts Institute of Technology. Here, working under the National Defence Research Committee, was body of scientists engaged in developing precision radar to ascertain the presence of enemy aircraft and to direct guns on invisible targets. A member of this group was a physicist, radiation expert and amateur pilot of the name of Dr. Luis W. Alvarez. Reasoning that this equipment, which had already attained a certain completeness and accuracy, could also be used to assist aircraft in making a proper approach to a landing, he obtained permission to conduct experiments along these lines. The first experiments in November and December, 1941, at Quonset Point Naval Air Station, Rhode Island, and East Boston Airport showed that gunlaying radar was not sufficiently accurate at low glide path angles, but that the " talk-down " principle was most feasible and practical. Dr. Alvarez then developed special radar antennae and a presentation for high precision radar at low angles, and combined this with a search system for traffic control. In this way a complete system resulted which, during the following months, was subjected to calibration tests in clear weather.

Colonel Stuart P. Wright, AAF Liaison Officer from the Office of technical services, had been by no means convinced by the East Boston test. But one day, during the autumn of 1942, with ceilings lowering to a minimum and snow flurries rolling in from the Atlantic, he set himself at the controls of a twin-engined Cessna " Bobcat " and cautiously felt his way up through the " soup ". At 2,000 feet, he radioed Dr. Alvarez, who was personally acting as master controller inside the radar van : " Bring me home ! " The scientist's quiet voice gave him the exact headings, instructed him to reduce his airspeed, to lower his wheels for landing... " You are 15 feet over the breakwater "—Colonel Wright, peering through the fog, could dimly make out the white outline of the breakwater surrounding the field—" You are now five feet above the edge of the runway... now two feet high... you will touch down in three seconds. " The Colonel began to count—exact to the second his wheels touched the runway—pushed the throttle forward and took off again ! " That was good, Luis, but that was only luck. Bring me in again ! " And after ten equally accurate landings the first experimental GCA model had well withstood its trials that day. Colonel Wright's enthusiasm knew no bounds.

In February, 1943, the radar van was brought to Washington, D. C., and demonstrated before high Army and Navy officers. The Government granted authority for the letting of contracts to private corporations for manufacture. As experiments progressed the Radiation Laboratory group with civilian engineers and representatives of the

Army and Navy finally developed the Mark I GCA, 57 units of which were manufactured for the Army Air Forces by Gilfillan Brothers, Inc., Los Angeles. Deliveries began in 1944.

At the same time, the Radiation Laboratory had already completed a new version, the Mark II. A Navy contract was given to the Bendix Radio Division, Towson, Md., who delivered the first test set in June, 1944. This was finally accepted by the Chief of Naval Operations in August, 1944.

The first installations at Army and Navy air bases were made in November, 1944. In the meantime, the original experimental model, the Mark I, was sent with the necessary operating personnel to England, where it was demonstrated to AAF and RAF units. Eventually it was turned over to RAF Coastal Command, and is still being used.

Towards the end of the war, the AAF alone possessed ten GCA units in Europe, three in the North Atlantic area, four in the fog-bound Aleutians in the North Pacific, and an additional ten in the Pacific.

At the end of 1946, there remained four in Europe, three to handle U. S. air operations at the Atlantic airports, three in Alaska, and eleven in the Pacific. Along with these, GCA units are in day and night operation at six AAF bases, and training units are located at two AAF bases and at one Naval base.

Dr. Alvarez, father of the new system, was no " arm chair " scientist. He flew with the AAF, Navy and RAF airmen in radar research, and later we find him as a group leader in the atom bomb development work at New Mexico. After witnessing the first atom bomb explosion at Alamogordo, N. M., he was chosen to be amongst those who, in a B-29, were able to follow the aircraft which dropped the atom bomb on Hiroshima. On December 17th, 1946, in the name of the National Aeronautic Association, President Truman officially awarded Dr. Alvarez the Robert J. Collier trophy, presented annually for " the greatest achievement in aviation in America, the value of which has been demonstrated by actual use during the preceding year. "

In order that they may be transferred from one airfield to another, the war-developed GCA units in operation today are mobile. The GCA station proper is housed in a trailer van, which is drawn by a four-ton truck containing two gas-driven generator groups and an air conditioner unit for trailer ventilation. Besides this, there is a spare parts truck which serves as a workshop.

The GCA unit is usually set up between 250 and 700 feet to the left of the centre line of the runway (as viewed in an approach) and between 3,000 and 5,000 feet from the approach end of the runway. Complete installation, which requires precise positioning, lasts about two and one-half hours, and only about 40 minutes for subsequent transfer to another runway.

Guiding aircraft into a fog-bound airfield with GCA may be broadly compared to bringing boats into a small harbour unknown to them, the entry to which is endangered by the presence of reefs and rocks hidden below the water surface. The harbour-master, who knows these obstacles, will begin by seating himself on the breakwater, scanning the horizon for approaching vessels with his telescope. As soon as one is sufficiently near, he will cease his scanning with the telescope, and will fix his naked eye on the ship requiring his assistance. Shouting port and starboard signals through a megaphone, he will guide it through the rock-infested area to safe anchorage. Once this is accomplished, he will resume his scanning with the telescope.

The " telescope " of the GCA set is formed by the *search radar*, which has a range of about 30 miles and supplies position information on aircraft within this radius and under 4,000 feet in altitude. This is made possible by producing 5-millionth-second, 2,000-times-a-second electromagnetic wave pulses, and transmitting them by means of a directional antenna equipped with a reflector, in the form of narrow beams. If a beam coincides with an aircraft, the latter will return the pulse wave ; the momentary direction of the beam, and the time interval between pulse transmission and reception, enable the aircraft range and position to be worked out. The aircraft also produces a luminous

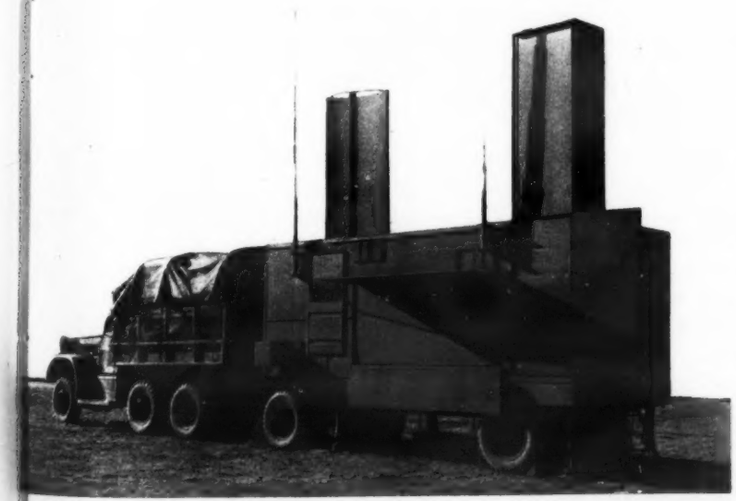
point on two screens which represent a rough map of the airport vicinity.

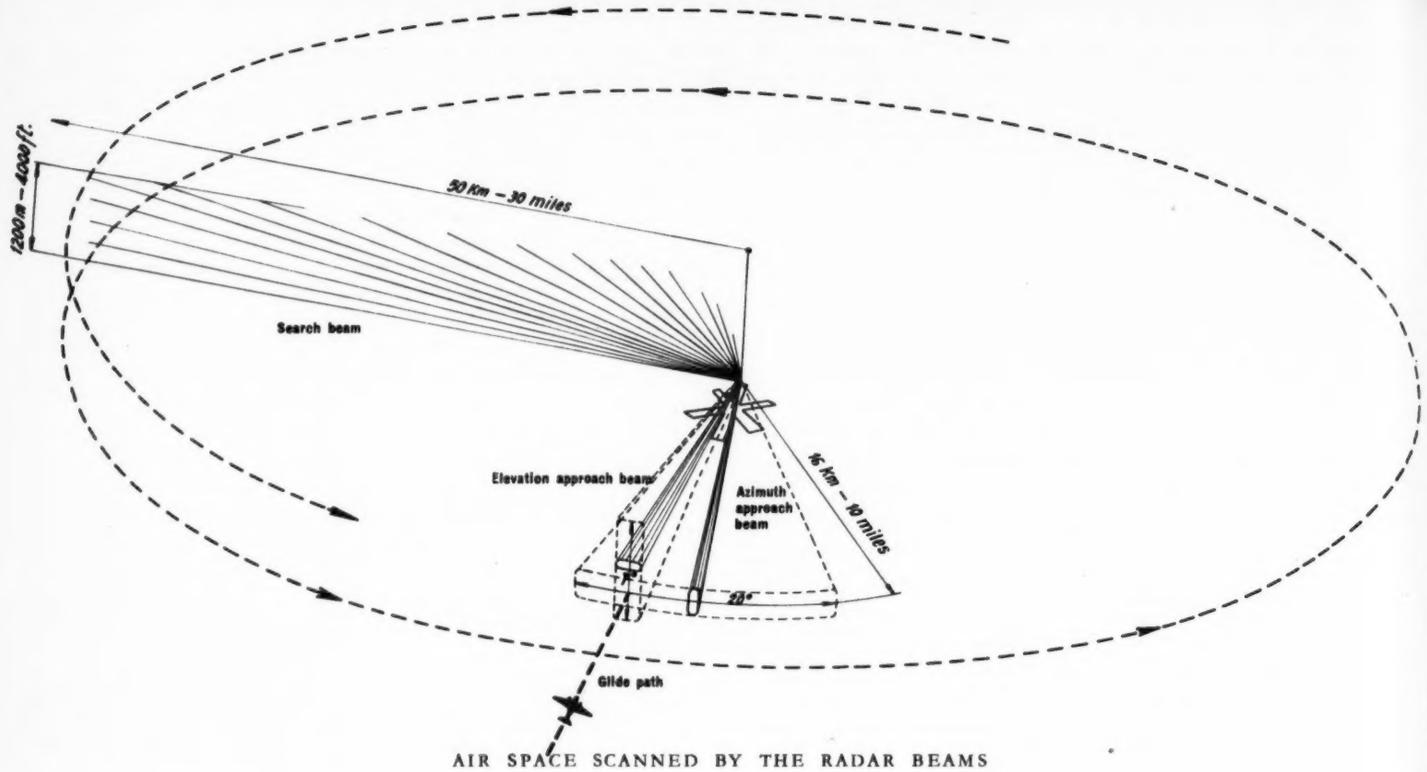
Two *radar precision systems* corresponding to the sharp eyes of the harbour-master, serve to obtain exact information on the distance, azimuth and elevation of the aircraft wishing to land. The beam of one of these scans 20 degrees in azimuth, giving the aircraft's distance and azimuth angle in relation to the station ; the beam of the other system, scanning six degrees above and one degree below horizontal, gives, in addition to its distance, the aircraft's elevation. Each of these two ten-mile range precision systems has two scopes : one showing the entire approach, the other presenting the last three miles thereof in correspondingly enlarged form. To facilitate tracking and scope reading, the elevation indications are enlarged approximately nine times and the azimuth three times. When a GCA set is installed and adjusted, the axis of the runway is marked on the azimuth scope and the prescribed approach path on the elevation scope by the use of known radar targets.

The GCA controllers who, in view of the high speeds of modern aircraft, lead a less tranquil life than our harbour-master, are not attributed as good an " eye-sight " as the latter. In fact the two scopes for the last three miles of the approach would not give the controller a sufficiently clear picture to track the aircraft quickly and measure its deviations from the prescribed path. To rectify this, there are two automatic *error-meters*.

To track the luminous dot, representing the incoming aircraft, the elevation and azimuth three-mile scopes each have a manually-worked hairline, known as a cursor ; its movements are extended to the error-meter adjusted to the runway in question, or to the prescribed approach path, which automatically measures the variance in feet between the cursor and the represented runway axis, or correct approach path, and indicates this on a calibrated panel. The azimuth

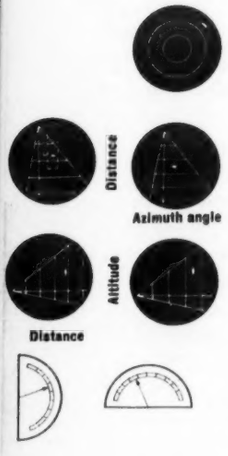
The mobile GCA unit. The truck contains the generators. The trailer contains the operating room with radar and radio equipment. The antenna equipped with a reflector, on the left side of the roof, rotates and sends out the search beam.





AIR SPACE SCANNED BY THE RADAR BEAMS

and elevation error-meters are grouped together on the approach controller's panel ; their purpose is to supply every necessary correction during the last stage of the aircraft's approach.



The position of aircraft within 30 miles radius of the unit, spotted by the search beam, are shown on the scopes before the No. 1 and No. 2 directors.

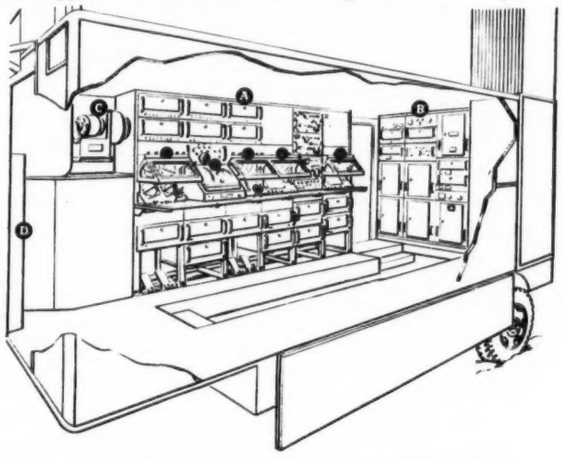
The scope before the *azimuth tracker* indicates lateral deviations from the " on course " within a sector of 20 degrees. The azimuth angle is enlarged three times ; the right-hand scope shows 10 miles of the approach, and the left-hand scope shows a corresponding enlargement of the last 3 miles before the runway.

The scope before the *elevation tracker* reveals the deviations in elevation from the glide path within a sector of seven degrees ; for facilitation of reading, these are enlarged nine times. On the right is the entire approach of 10 miles ; on the left, the last section enlarged.

The instruments before the *approach controller*. On the left, elevation deviations and on the right, azimuth deviations from the pre-determined approach path.

Recording instruments of a GCA station.

which is located a look-out window. The transmission equipment occupies the end wall to the right of the operators. The air-conditioning system is appreciated when it comes cooling the instrument panels and



Location of equipment and operators in a GCA van :

A) Recording instruments
1) Elevation tracker.
2) Approach controller,
3) Azimuth tracker,
4) No. 2 director.
5) No. 1 director.
B) Transmission equipment.
C) Blower to ventilate instrument panels.
D) Current distribution switch board.

As for ability to speak and hear, the GCA set need not envy the harbour-master ; it has no less than six " megaphones " and six " ears " to make itself understood by six " ships " simultaneously : six radio transmitters and six radio receivers for oral communication. Three of the two-way groups operate on the HF band of frequencies (2-18 mc) and the other three on the VHF band (100-156 mc). All six groups are controlled by a system of push buttons which are available in duplicate panels to all operators in the GCA van.

All the above-mentioned equipment is arranged in detachable groups inside the trailer. Along one of the walls is the equipment requiring constant servicing and in front of which are seated the five crew members assigned to each unit. To the rear of these operators is the receiving equipment not requiring constant supervision, between making it possible to breathe inside the small available space of the van.

To familiarise ourselves with the duties of each operator and the equipment before him, we must begin with the right-hand end crew station.

That is where the *No. 1 director* sits, whose duty is to establish communications and radar contact with the in-coming aircraft. Before him he has a search radar scope : his " telescope " for scanning the skies. An aircraft within his " field of vision " appears as a luminous dot on the scope, so that he has the possibility of recognising an eventual danger of collision between two aircraft, for instance. As soon as a pilot applies to him for assistance, he gives him the necessary information concerning altimeter setting, field elevation, length and width of the runway, and such other data as may be important for a landing.

Let us listen to " Navy 51303 ", a twin-engined Beech SNB trainer (military version of the Beech 18 feeder transport) calling GCA unit " Robin " :

— (Hello) Robin — This is Navy five one three zero nine — Request ground controlled approach — Over.

(" Over " means : my transmission is ended and I expect a response from you.)

— (Hello) Navy five one three zero nine — This is Robin (No. 1. director) — Roger — What is your altitude, heading and approximate position — Over.

(" Roger " means : I have received and understood your last transmission.)

— This is three zero nine — Altitude four thousand, heading one nine zero, north of airport — Over.

(The aircraft indicates heading in compass degrees. Heading 190 is thus approximately south.)

— Roger three zero nine — Fly at three thousand feet — Altimeter setting two nine nine six — Over.

(Altimeter is set in accordance with a sea level pressure of 761 mm Hg.)

— Three thousand feet — Altimeter two nine nine six — Three zero nine.

— Three zero nine — Report over station WGGA — Twelve forty kilocycles (or report over the range station or report over the radar beacon station, whatever the case may be) — Over.

— Report over WGGA — Three zero nine.

— Three zero nine — What is your aircraft type — Over.

— Aircraft SNB — Over.

— Aircraft SNB — Roger — Out.

(" Out " means : my transmission is ended and I expect no response from you.)

The aircraft now proceeds to station WGGA, which instructs him as to the point over which he must wait until given permission to land. The pilot then reports his arrival.

It can happen that the air traffic is too dense for the GCA unit straight away to handle all incoming aircraft in the afore-mentioned manner. However, it is most often the case that these are already in communication with the airport control tower while nearing the field, and are thus in possession of information concerning landing possibilities. If the runway and GCA unit are engaged by other aircraft, it is then up to the control tower to order the newcomer to fly in a zone characterized by a radio fix or such-like, at a determined altitude to and fro in a direction transverse to that of the runway. These " holding patterns " assigned to each aircraft are at altitude intervals of about 1,000 feet, so that there results a " stack " of aircraft flying to and fro.

As soon as No. 1 director informs the control tower that he is ready to take over another aircraft, the pilot flying the lowest holding pattern receives instructions from the control tower to give the GCA trailer a call on a certain frequency. Subsequently, the tower orders each aircraft in the stack to descend 1,000 feet, so that each ultimately arrives into the last holding pattern ready to be landed.

If our Beech SNB had arrived during a period of heavy traffic, it would not have been able to make immediate contact with the GCA unit, but would have been assigned by the control tower to the top holding pattern of the stack. Only after gradual descents would it have been permitted to call the GCA van. Once it had arrived over the radio beacon, the subsequent conversation would not have differed essentially from the previous one :

— This is three zero nine — Over WGGA at two seven — Three thousand — Over.

— Three zero nine — Roger — Steer one zero five — Over.

— Steer one zero five — Three zero nine.

(The aircraft then takes an easterly heading, as denoted by 105 degrees. The No. 1 director now orders a small change in heading to simplify identification on the scope.)

— Three zero nine — Steer left zero seven zero — Over.

— Left — Zero seven zero — Three zero nine.

— Three zero nine — Steer right one one zero — Over.

— Right — One one zero — Three zero nine.

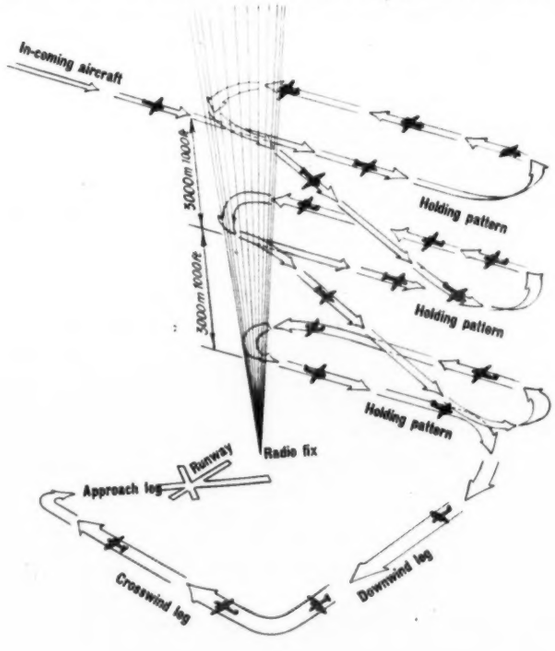
The No. 1 director now sees him :

— Three zero nine — Have you in sight four miles north east of the airport on your downwind leg — Over.

— This is three zero nine — Understand in sight four miles from airport on downwind leg — Over.

It is now the moment to prepare for landing. Flying downwind parallel to the runway, the aircraft will presently turn in order to enter the so-called crosswind leg of the runway axis, and finally turn upwind into the approach leg. No. 1 director gives him his last instructions :

— Three zero nine — You will be landing on runway two nine — Perform landing cockpit check — Over.



General stacking procedure, as used for Ground Controlled Approach.

GCA crew in action.

In the foreground is the approach controller, on his right is the azimuth tracker and alongside the latter is the No. 2 director. No. 1 director is momentarily absent. The photo is taken from the elevation tracker's station.

— Runway two nine — Cockpit check — three zero nine.

At the order " landing cockpit check ", the wheels and landing flaps are extended and all other preparations for landing made. Number 29 indicates the runway to be approached at a heading of 290 degrees.

To the left of the No. 1 director in the radar van is the *No. 2 director*. He has a scope identical to that used by the former. His duty is to enable No. 1 director to assume control of additional incomers, and to guide the aircraft in the approach leg until touch-down. The pilot need not shift channels on a GCA approach as all this is done in the trailer. No. 1 director now calls No. 2 director on the inter-com :

" Three zero nine at six miles, four o'clock, three thousand on one one zero — Unit two. ".

The No. 2 director then glances at his scope and switches on set No. 2, the channel of which is already established.

— (Hello) Three zero nine — This is Robin (No. 2 director) — How do you hear me — Over.

— Robin — This is three zero nine — Read you R-5 S-5 — Over.

— Roger three zero nine — Steer right one six zero — Over.

— Steer right one six zero — Three zero nine.

— Three zero nine — You are on your crosswind leg — Seven miles from the airport — Fly at two thousand five hundred feet — Over.

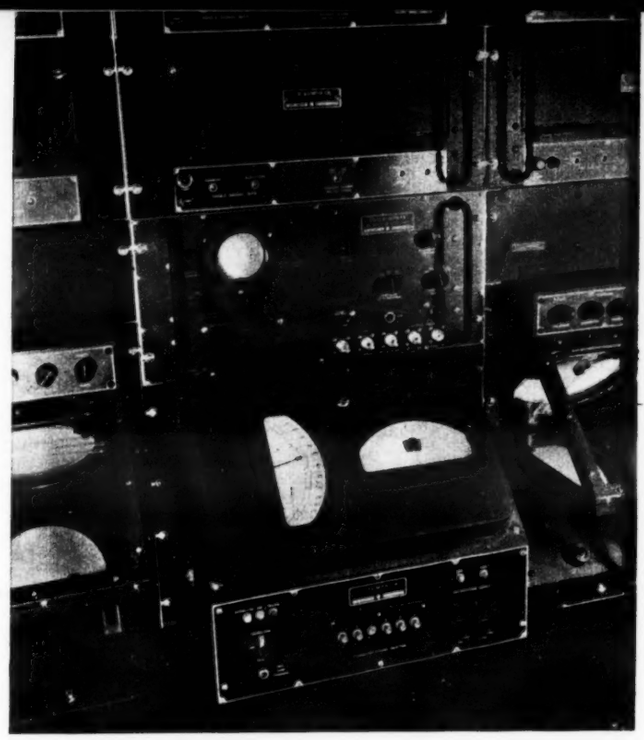
— Crosswind leg — Two thousand five hundred — Three zero nine.

— Three zero nine — Steer right two zero zero — Over.

— Steer right two zero zero — Three zero nine.

The " telescope " of the GCA station may now be dispensed with. The aircraft is within " eye range " of the precision systems and can be observed " with the naked eye " up to the landing. This important phase is shared by three crew members in the van : the azimuth tracker, the elevation tracker, and the approach controller.

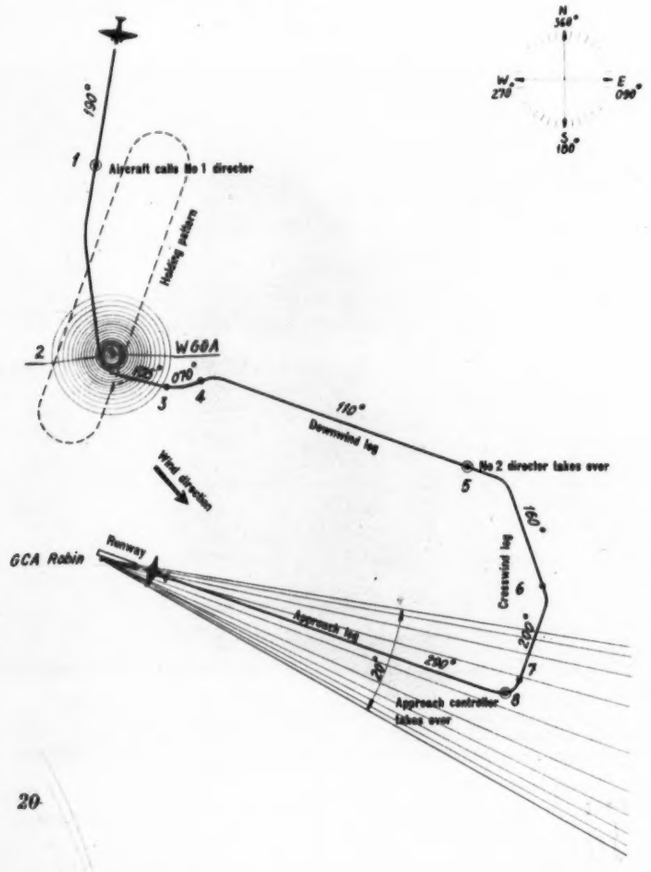
The *azimuth tracker* faces the two azimuth scopes, and the *elevation tracker*, the two elevation scopes. The sole duty of both is to track the aircraft with the cursor, thus transferring the measurements made by the precision systems to the error-meters. The *approach controller* sits between them and faces the azimuth and elevation error-meters. He is responsible for " talking down " the aircraft by constantly emitting oral instructions to correct any deviations from the prescribed approach path.



Approach controller's instruments.

The instrument on the left gives the deviation in elevation and that on the right the deviation in azimuth from the glide path. On either side one can see the scopes of the elevation and azimuth trackers, whose duty is to track the luminous dot, representing the aircraft, with a cursor.

Flight of Navy 51309 until landing with aid of station WGGA and GCA Robin. These currently instruct him on his heading ; the aircraft's positions on reception of such instructions are identified by numbered dots.



No. 2 director informs these three operators over the inter-com that the landing is about to take place :

" Three zero nine is coming from left to right two thousand five hundred, seven miles, channel No. 2, will be in a sweep in fifteen seconds. ".

In the meantime, the aircraft has almost reached the runway axis. He is instructed on his final curve :

— Three zero nine — Steer right two nine zero — Over.

— Steer right two nine zero — three zero nine.

The approach controller switches on the error-meters and takes over :

— Three zero nine — Come out of your turn on two nine zero and hold present altitude — Over.

— Heading two nine zero — Present altitude — Out.

— Do not acknowledge any further transmissions. You are on your final leg. Steer left two eight five... You are six and one half miles from the runway... Present heading O. K.... Start losing altitude at five hundred feet per minute... Steer right two nine zero... Five miles from runway... Sixty feet above glide path — Adjust rate of descent... Forty feet above... Twenty feet above... On glide path... Present heading O. K. — Hold two nine zero... Four miles from runway... Clear to land — Wind north west ten... Twenty feet below glide path going lower... Adjust rate of descent... Three miles from runway — Check gear down and locked — Present heading O.K. — Track very good... Two miles from runway... On glide path... One mile from runway — Steer right two nine zero... Going above glide path — Adjust rate of descent... Twenty feet above... Forty feet above... Fifty feet above... You are now correcting on to the glide path... Forty feet above... Twenty feet above... On glide path... One half mile from end of runway... On glide path... Over end of runway — On course — On the glide path...

The pilot can now perceive the ground — he has landed.

T.

The Air Hostess Told Us...

Scandinavian Brothers

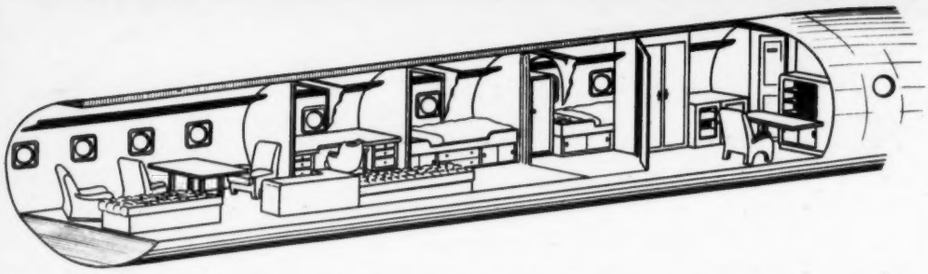
We are talking about those Scandinavians. Well, they are known to be good sea and airfarers. The Swedes are out in front, Norwegians and Danes not far behind. In 1943—in the middle of the war—Swedish industrial, shipping and commercial interests founded SILA (Svensk Interkontinental Lufttrafik A. B.) to operate intercontinental air services. They arranged for it to collaborate intimately with ABA (A. B. Aerotransport), Sweden's State-controlled continental airline. Thus, the two Swedish airline *dioscuri* shared the tasks at hand: Captain Carl Florman became continental, Per A. Norlin intercontinental. Furthermore, the programme provided for close co-operation with Norway and Denmark, theoretically also with Finland. Washington was all in favour of the scheme, as it eliminated the need of giving separate landing rights to each country. The original set-up was purely Swedish and quite astute: to avoid duplication, SILA was to fall back on the technical equipment, personnel and experience of ABA, which in turn was backed by the Treasury. Hence, SILA originally seemed to be nothing but the overseas division of ABA, with the difference that the former firmly intended to remain privately controlled. This resulted in *one* discrepancy: for ABA, which now has a Government-controlled share capital of Kr. 11,080,000 and additional means in the form of loans from a Government fund, requires new money for its own operations and those of SILA. But when the company decided to raise the money in the open market, the Swedish Government objected. The Government's money and private capital must not be mixed up to such an extent, they said, as to leave the State with a minority interest. As a result, the question of whether the original arrangements between the State-controlled ABA and the private SILA would be acceptable to the Government in the long run or not suddenly came to a head. Sweden has a Socialist Government and is used to State monopolies of all sorts. A certain uniformity in clothing, food and habits is quickly discernible in Sweden. Why no uniformity in the civil air services? Why not another State monopoly? Because banks and shipping companies are against it. — The *other* discrepancy arose after the war when the Scandinavian joint operating company, the *SAS (Scandinavian Airlines System)*, gradually evolved from the purely Swedish SILA. This occurred at the beginning of 1946. Norway, represented by DNL, her national airline, and Denmark, represented by her DDL, joined the group. SAS was split up: the Swedish SILA got a three-sevenths share, the Norwegian DNL and Danish DDL two-sevenths each — though for all practical purposes the latter two companies were State-controlled concerns. The plan was based on an excellent idea: outsiders were confronted with a Scandinavian *air bloc* constituted by the Scandinavian Brothers. But internally? The Swedes *are* the strongest, they have done all the spade work, they furnished most of the finance, and—perhaps without intention on their part—SAS was more often referred to as a Swedish than a Scandinavian enterprise. And now mountains were made out of molehills. A Swedish paper wrote about a Danish DC-4 which lost an engine cowl in flight that "a Swedish 'Skymaster' is in danger". The Danes were offended. When a Swedish reporter flew home from South America, he reported that the "Swedish SAS" were the masters of the South Atlantic. The Norwegians were not very enthusiastic. All this is now going to be straightened out, for unity means strength. *SAS is to be reorganised and its holdings revised.* General Hjalmar Riiser-Larsen, the Norwegian airman, has joined the management of SAS. He and the *spiritus rector* of the scheme, Per A. Norlin, are friends of long standing. Routes and equipment are being assigned to the different Scandinavian main airports. The four Boeing "Stratocruiser" four-engined airliners to be delivered to SAS in 1948 — a little overdue! — will be based at the Norwegian airport of Stavanger-Sola. This will shorten the Atlantic route. The seven four-engined Douglas DC-6's contracted for, delivery of which is to begin in 1947, will first be stationed at Stockholm-Bromma, subsequently at the new Swedish intercontinental airport at Halmsjön. They will be used on the SAS services to the Far East and Australia. The seven Douglas DC-4's now in service will go to Copenhagen—Kastrup for use on the African services and in charter operations. The twin-engined Douglas DC-3's are not even mentioned... Finally, SAS is to be legally registered as an incorporated company and assume sole responsibility as the holder of traffic, flying and landing rights. The air crews consist of Swedes, Danes, Norwegians, Americans and Britons —mostly Americans for the beginning. By March, 1948, the flying personnel is to number about 700! — As you see, SAS will be a big Scandinavian concern, even though it is expected initially to operate at an loss. But, hovering at the back of the Scandinavian idea is an *unsolved Swedish problem*. The Norwegian and Danish partners, DNL and DDL, are State-controlled concerns. The Swedish partner, SILA, is privately owned. Will the private SILA merge with the Swedish Government's ABA and become a State-concern in turn? This is a question of fundamental importance, the answer to which will be not so much a verdict on the respective merits of the two systems as a final clarification of circumstances.

Special Flights — Air Yachts....

There were times when heads of States and people in a hurry and with lots of money ordered a special train. A thing of the past! In the inter-war years already, press tycoons and captains of industry had their own air yachts built. Britain's Lord Beaverbrook was worked up into the necessary state of enthusiasm by Switzerland's Mittelholzer and bought his own twin engined Lockheed. When Belgium's industrialist Löwenstein intentionally or unintentionally fell out of his air yacht, a three-engined Fokker, this wasn't the fault of the aeroplane. — Be that as it may. Will the rich again buy their own aeroplanes or charter aircraft for prolonged periods of time? There isn't a doubt. Douglas are converting some of their old DC-3's into luxurious "executive transports", and Mr. B. van Leer, a Netherlander, who with the manufacture of petrol drums is making several continents happy and a pile of money at the same time, has chartered a Douglas DC-4 from KLM Royal Dutch Airlines for the period from March 12th to May 4th, 1947. The machine will be used for a trip to the Far East, to East, South and West Africa. The gentleman likes his comfort: for the trifle of forty thousand Dutch guilders the aircraft will receive a special "shampoo and set" from a noted firm of interior decorators in The Hague. There will be a crew of eight, ranging from flight inspector and aircraft captain down to cook, valet, steward and travelling photographer. The dollar jingles, but, you see, so does the guilder: it has made a rapid recovery! Rich people are still to be found everywhere, and "Flying

Douglas DC-4 "Nordan" of SAS. Noticeable is "SILA, Sweden" marked inconspicuously on the nose.

Douglas DC-4 "Gardermoen" of SAS. The three Scandinavian coats-of-arms are marked towards the fuselage rear.



Interior lay-out of the Douglas DC-4 " Twenthe " of KLM Royal Dutch Airlines, for B. van Leer's special flight.

Dutchmen " never die, they don't even fade away... Let us hope that other nations will also get back to reason, for the benefit of aviation.

Confidence Unshaken

The same as other airline companies, Air France machines were involved in a few accidents in the winter of 1946-47. It so happens that until France's economics become stabilised, French affairs will be closely scrutinised by observers in foreign countries — and remorselessly criticised by the French themselves. A Parliamentary debate and vote in the second half of February cleared the air, so far as civil aviation is concerned. A few days before the vote an incident due to an outbreak of " Fire on Board ", described elsewhere in this issue, had furnished proof of the air crews' level-headedness. And in the Parliamentary debate Transport Minister Jules Moch found it easy to defend not only Max Hymans, his Director-General of Civil Aviation, but also the Air France management, its crews and staff and the entire personnel working for the French civil air services. The causes of the mishap were cleared up. A five-year plan involving an expenditure of 250,000,000,000 French francs has been adopted to improve air safety and ground organisation. (Let us hope that the French deputies will not cut the financial appropriation too sharply.) And here is the *Vote of Confidence* by the French National Assembly : " ... It appreciates the Government's strenuous efforts to reorganise the commercial air services and expresses its full confidence in these measures. In order to accomplish this task, the Government should submit its financial requirements in the form of draft legislation in the nearest future. Of paramount importance are : the rapid improvement of radio and meteorological services and all ground facilities, to ensure maximum air safety in metropolitan France and all the territories connected with it. "

MAX HYMANS, D. Sc. Director-General of French Civil Aviation.

Politics Interfere with Air Traffic — In Italy too

Even Italy's best friends will find it difficult to make head or tail of the names of the three largest Italian airline companies. Just watch : LAI (Linee Aeree Italiane) is the Italo-American company formed with the aid of TWA. ALII (Aero Linee Italiane Internazionali) — which itself seems to be anticipating trouble since it calls itself Ali d'Italia for publicity purposes — is the British-Italian airline established with the help of BEAC. Finally, there is the old ALI (Avio Linee Italiane). All three companies — not to mention the host of smaller ones — plan to inaugurate air services in the near future. But this inauguration is inevitably preceded by a minor political " ouverture ". The Sicilian Deputy Aprile has demanded an enquiry into the activities of ex-Air Ministers Cevolotto and Cingolani as well as of Air General Luigi Gallo, ex-Director-General of Civil Aviation. All these people are accused of having favoured the Americans when the various air traffic arrangements were drafted. And for weeks we have read in the Italian newspapers that Italian civil aviation had been sold out to foreign interests. One may wonder what there was to sell when Italy collapsed. But more important than squabbling would seem to be to start flying again just as soon as possible.

EEH.

PICAO Air Navigation Meetings

Among the most important duties of the Provisional International Civil Aviation Organisation is the working out of technical norms for inter-State air traffic and the introduction of corresponding safety measures. Certain articles [1] published in " Interavia Review " already gave an idea of the multiplicity of these tasks. Entirely the responsibility of the PICAO Air Navigation Committee, the solution of this multitude of technical problems requires thorough knowledge of the separate fields and familiarity with local conditions prevailing in the traffic areas to which the measures are to be applied. For this reason the Committee is aided on the one hand by special sub-committees, the so-called Divisions, dealing with these separate fields, and on the other hand by Regional Air Navigation organisations. The main Committee is sufficiently occupied with preparing for the sessions of these groups, controlling their work, studying and weighing up their recommendations, and submitting its views for final approval by the Interim Council.

Below is a brief outline of the activity of these PICAO organs during the last months.

Opening session of the PICAO South Pacific Regional Air Navigation Meeting, in the 'Wilson Hall of Melbourne University.

AIR NAVIGATION COMMITTEE

During this period the Committee (re-elected as Chairman, A. R. McComb, Australia) has met almost without interruption in order to cope with the reports of the Regional Conferences for the North Atlantic (Dublin, March 4th-27th, 1946), European-Mediterranean (Paris, April 24th-May 15th), Caribbean (Washington, August 26th-September 13th) and the Middle East (Cairo, October 1st-18th) and to prepare them in readiness for the series of Division meetings beginning on October 29th (see below). The creation of a special Medical Division was also discussed. The Committee allowed itself only a brief respite from work, from December 10th, 1946, until January 9th, 1947.

SOUTH PACIFIC REGIONAL CONFERENCE

The fifth Regional Conference of PICAO was held from February 4th to 22nd, 1947, in Melbourne. Its purpose was to organise air navigation in the entire Pacific south of a line extending from Vancouver through Hawaii to Shanghai, and including the Philippines, New Guinea and Australia. The proceedings were attended by over one hundred delegates of seventeen Member States. The Australian Director-General of Civil Aviation, Air Marshal R. Williams, was elected Chairman, and the President of PICAO, Dr. Edward P. Warner, was in Melbourne for the opening. The Conference was considerably aided by valuable work accomplished beforehand by the British Empire's own organisations, and its decisions should allow for a co-ordinated use of the extensive network of Pacific air installations erected during the war.

REGIONAL SECRETARIATS

All the Regional Conferences of 1946 decided on the establishment of Permanent Secretariats. Three of these commenced work at the beginning of this year and are situated :

for the *North Atlantic*, in *Dublin*, Fitzwilliam Place 7. Secretary : Group Captain Eric M. Lewis ; Assistant : R. S. Parker ;

for *Europe-Mediterranean*, in *Paris (16e)*, Avenue d'Iéna 60 bis. (Tel. : Passy 37-34). Secretary : Lionel Bedin ; Expert on Communications : W. Miles ;

for the *Middle East*, in *Cairo*, 10 Sharia Lotfalla, Zamalek. Secretary : Daniel Lefèvre.

DIVISION MEETINGS

Brief mention may be made of the second annual series of meetings of the PICAO Air Navigation Committee's Divisions during the 1947/47 autumn and winter months, with their inaugural dates :

October 29th :	Meteorological
October 30th :	Special Radio Technical
November 19th :	Communications
November 26th :	Search and Rescue
December 3rd :	Rules of the Air and Air Traffic Control
January 7th :	Personnel Licensing
January 14th :	Aeronautical Maps and Charts
February 4th :	Accident Investigation
February 20th :	Airworthiness
February 25th :	Airline Operating Practices.

The Division on Aerodromes, Air Routes and Ground Aids held its first meeting in July, 1946, and has not been convened since. Meanwhile, the Interim Council has decided that, for the next eighteen months, all airports used in North Atlantic operations should have runways of 5,900 ft. in length and 135,000 lbs. load bearing capacity (90,000 lbs. is temporarily permitted). Runways at alternate airports must be 5,000 ft. long with 60,000 lbs. load bearing capacity.

[1] Dr. E. P. Warner : Six Months of PICAO, Vol. I, No. 1, April, 1946 ; A. G. Lamplugh : International Handling of Air Accidents, Vol. I, No. 2, May, 1946 ; L. Clerc : The First Plenary Session of PICAO, Vol. I, No 4, July, 1946.

Sovereignty and Civil Aviation

Preparing for the ICAO Plenary Session,

Montreal, May, 1947

I. May Manolete Disembark ?

It is Sunday, and Manolete, bullfighter and idol of Madrid, is due to appear in the Barcelona arena. Early in the morning, in full war paint, he is at the airport to learn, to his dismay, that the Iberia plane is not taking off. A bright sun shines mockingly from a deep blue sky, but still, no take-off. What the bull had never managed to do, the clock did. Manolete is nervous. But there is another aircraft on the runway !

" Ho there ! Where goes the great bird ? "

" 'Tis the Madrid-Barcelona-Geneva-Stockholm plane of the ABA, of Sweden, *senor,* " replied the airport attendant. " It leaves in 25 minutes. "

An instant later Manolete is at the ticket booth asking for a ticket for Barcelona. But only to hear that, though the ABA plane would land at Barcelona, Manolete could not travel by it because... a certain agreement between Governments... this being a foreign carrier... foreign competition on national soil...

Presence of mind is the primary tool of the *torero.*

" A ticket for Geneva, please ! "

And 30 minutes later, the ABA aircraft sets him down, softly on the Barcelona runway. But it is not the baleful glare of the bull which first meets his eye. It is that of the airport official.

" You may not disembark, *senor.* Your ticket is marked ' Geneva ' Consequently you must fly on to Geneva. "

But the airport official did not reckon on the *torero's* lightning re-action.

" Sure, I'm going to Geneva. But tomorrow. I'd like to have a look round Barcelona today. "

Disgruntled, the official, not knowing any regulation to the contrary, finally let Manolete through the gates. Whether he broke into Manolete's hotel bedroom early on Monday morning to pack him off to Geneva, is not known for sure. Certain, however, is that our hero of the arena learned that day that not only bulls, but also the sky required handling with all the dexterity of the *torero.*

II. The Insurmountable Wall

Why, precisely, it was forbidden for ABA to fly Manolete from Madrid to Barcelona may be explained in two short sentences :

" The High Contracting Parties recognise that every power has complete and exclusive sovereignty over the airspace above its territory, "

and :

" The contracting States recognise that every State has complete sovereignty over the airspace above its territory. "

The logical remark is : but they both mean exactly the same. However, the legal know-all soon quashes that : the first sentence is taken from Chapter I, Article I, of the Paris Convention of 1919 (ICAN) ; the second sentence, from Part I, Chapter I, Article I, of the Convention on International Civil Aviation, of Chicago, which as from May, 1947, is to establish internation aviation relations on an " *entirely new basis* ". Between the two resolutions is a span of 28 years. Many inter-State air agreements were ratified during this period : The U. S. A. and certain of the Central and South American States concluded the Havana Convention in 1928 ; in 1944, PICAO was formed in Chicago ; on October 30th, 1946, the ICAN, offshoot of the Paris Convention, decided on its dissolution. But, whether it concerns multilateral conventions of world scope, or merely two-way pacts, the above sentence, *expressis verbis,* occurs invariably. There is absolutely no avoiding it, and the full import is deftly and wittily expressed by Dr. Warner, President of the PICAO Interim Council, in his first lecture delivered at McGill University on January 10th, 1947 :

" Nothing in international law is better established than that the sovereignty exercised by governments extends indefinitely upward. *Ab inferno usque ad coelum* was the ancient legal phrase for defining the vertical extent of property rights in real estate. We are now somewhat less certain of our celestial geography than Blackstone was, and we might define sovereign rights as extending from the ionosphere above to the centre of the earth below, rather than from Heaven to Hell ; and in any case individual property rights in airspace have suffered substantial attrition, insofar as the right to take action against aerial trespassers is concerned ; but the upward extension of national sovereignty remains intact. Any aircraft in flight over any part of the earth's surface, except the high seas and a few limited areas of undetermined sovereignty, is continuing its flight by the express or implied grace of some national government. "

III. The State Recognises No Higher Authority

Next May, representatives of the airfaring nations will once more meet in Montreal. The question will again arise as to whether the various States are willing or not to bargain one way the other with their established air sovereignty rights. For all negotiations, bilateral and multilateral, insofar as they could be brought to satisfactory conclusions, were for this specific purpose. The results obtained are not brilliant. And there exists a good reason why. We are living in a time where the juridical layman has ample occasion to observe the scope of every international organisation. During the past thirty years, we have been able to see, occasionally to experience closely, that the Law of Nations is devoid of any means of peacefully enforcing

EDWARD P. WARNER,
President of the PICAO Interim Council.

observance of recognised international laws. Still less will States let themselves be forced—by what court, anyhow—to accept new principles and to agree to the freedom of the air. One can complain of PICAO's lack of power. One can even go so far as to demand that PICAO have the right simply to decree freedom of the air. But there remains a fact which cannot be denied, namely, since the disappearance of spiritual might with the close of the Middle Ages, there has existed no supreme court which could compel a sovereign power to relinquish any part of its sovereign rights. The League of Nations was no more able to do it than was the Holy Alliance. And, unless the stars tell lies, the power of UNO will find its limit there, and precisely there will the nations cease to comply with its rules. The French exponent of the Law of Nations, Georges Scelle, in his textbook on international public law, begins the chapter on the possibilities of executing the Law of Nations, with the sentence : " It may appear paradoxical to speak of an executive function in the Law of Nations... "

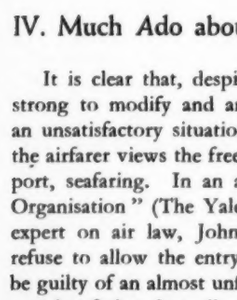
If one places the future International Civil Aviation Organisation within this larger, historical framework, one's astonishment at its lack of competencies is not quite so great as when one considers the question unconditionally and simply ascertains that *ICAO's wings are clipped.* There is no denying that its competencies do not stretch very far. The only matters in which ICAO's decisions carry any real weight are those of a technical nature, such as air navigation, for instance. But as soon as the decisions bear upon economic consequences, the authorisations to fly certain routes, the establishment of fares, frequencies or capacities, ICAO's authority begins to deflate. It may " study " these questions, have them " examined " by its committees, and submit " unconditional suggestions " to Member States. In Article 44, Section e, of the Convention on International Civil Aviation, it is stated that ICAO's purpose is to " *prevent economic waste caused by unreasonable competition.* " *But ICAO has been given no means with which to attain this end.* It has no power whatsoever to bind a State to any of its decisions.

All of us who are interested in the development of international air transportation must make the best of this fact. It may console some if we remind them that our cherished world air organisation shares the destiny of all other bodies based on the Law of Nations, whether they function as juridical or as administrative organisations. The Hague Tribunal, the International Red Cross, the International Labour Office—all organisations and bodies dealing with the Law of Nations, of international legal identity or not—lead a Cinderella existence. They stand under a shadow and have to be glad if the sovereign powers, who alone have real authority—who not only have competencies, but also the power to decide themselves just to what point their competencies extend (competence-competence)—allow them to continue breathing.

IV. Much Ado about Nothing

It is clear that, despite all these setbacks, the desire still remains strong to modify and ameliorate, to as great an extent as possible, an unsatisfactory situation. It is with a certain amount of envy that the airfarer views the freedom enjoyed by an associate branch of transport, seafaring. In an article entitled : " Air Transport and World Organisation " (The Yale Law Journal, August, 1946), the American expert on air law, John C. Cooper, points out : " Any State may refuse to allow the entry of aircraft of a second State, but it would be guilty of an almost unfriendly act if it refused the entry of merchant vessels of that State. " Cooper recalls how in the XVIIth Century the father of the modern Law of Nations, the Dutchman, Hugo Grotius, fought for freedom of the seas. In his celebrated dissertation : " The Freedom of the Seas or the Right which belongs to the Dutch to take part in the East Indian Trade ", he laid down the principle, which has since become the foundation stone of international maritime law, that : " *Every nation is free to travel to every other nation, and to trade with it.* "

In Grotius' time, people were willing to be persuaded by arguments based on logic and rights. And, of probably still greater influence, was that the subsequent rapid development of traffic on the high seas occurred during a period which offered unobstructed free trade opportunities. Air transportation cannot hope to acquire the same freedom in the same spectacular way. A mass sweep-forward will not enable it to break through the closed portals of the world, portals sealed by tight regulations covering every field of international activity. It must still plod ahead, however, and the only means as yet discernible are bilateral and multilateral air agreements.



JOHN C. COOPER,
aerial legal adviser, U. S. Delegation, Chicago Conference, 1944 ; official observer, first PICAO Assembly, Montreal, 1946.

V. The Story of the Bermuda Plan

The bilateral air agreement signed at Bermuda on February 11th, 1946, between the U. S. A. and Great Britain, which has since served as pattern for a number of further two-way air pacts, will come up for debate next May in Montreal. *Member States of ICAO will then have to decide whether the Bermuda Plan can be regarded as a suitable basis for a multilateral agreement.*

In an article entitled : " The Bermuda Plan : World Pattern for Air Transport " (Foreign Affairs, October, 1946), John C. Cooper arrives at the conclusion that the Bermuda Plan could easily become the basis of a general international air transport convention. On the other hand, he leaves no doubt that, as it stands in its present form, differences do exist in its interpretation, and that these should be clarified before submitting it for acceptance by ICAO.

Meanwhile, far more critical voices than Cooper's have been raised. General L.-M. Chassin writes in the French " Revue de Défense Nationale " of February, 1947 :

" This agreement, which has been criticised sharply in the British House of Commons by Lord Swinton, Conservative Member and former Minister of Civil Aviation, is so unclear in certain places that its application to both sides of the Atlantic is by no means uniform... Before the Bermuda agreement could ever serve as pattern for an internationally-accepted air convention, its implications would first have to be interpreted more clearly by PICAO... "

What led up to the Bermuda Plan ? To be precise, it represents an emergency solution. It is a compromise designed to enable Anglo-American civil aviation to get going all the same, despite the disappointing outcome of the Air Transport Agreement formulated in 1944 at Chicago.

It will be recalled that, at the Chicago Conference, three different plans were urged for the regulation of international civil aviation. The U. S. A. was in favour of complete freedom of operation with no economic or political control by an international body. Great Britain and Canada proposed the establishment of an international organisation with the power economically to fix and grant routes, frequencies, capacity and rates. Australia and New Zealand, fearing the political outcome of international competition, urged world ownership of all major international operations, with only minor routes flown under national flags.

If at Chicago it had been insisted on that economic control be applied to world aviation, there would have been no agreement between the powers. As it was, negotiations were limited to the establishment of PICAO, the drafting of the Convention on International Civil Aviation (ICAO) and the opening for signature of two agreements embodying five principles to cover the economic problems. The International Air Services Transit Agreement (" Two Freedoms ") offered no difficulty, as the privileges of flight over, or landing for refuelling, in the territory of accepting States had been established in the Paris Convention of 1919 (ICAN, Chapter 1, Article 2).

But the remaining three freedoms, incorporated in the International Air Transport Agreement, bit deeply into the States' economic sovereignty rights. Acceptance of :

1. The privilege to put down passengers, mail, and cargo taken on in the territory of the State whose nationality the aircraft may possess (Third Freedom);
2. the privilege to take on passengers, mail, and cargo destined for the territory of the State whose nationality the aircraft possesses (Fourth Freedom); and
3. the privilege to take on passengers, mail, and cargo destined for the territory of any other contracting State and the privilege to put down passengers, mail and cargo coming from any such territory (Fifth Freedom),

would effectively infer nothing else than the introduction of *full freedom of trade, as proposed by America and rejected by Great Britain.*

It is readily understandable that Great Britain, Canada, Australia and New Zealand did not ratify the Transport Agreement, and that, apart from the U. S. A., only a few nations, of small influence in international aviation, accepted it. But on July 25th, 1946, even the United States renounced it. In this way disappeared the last hope of any economic regulation of civil aviation by medium of the "Five Freedoms" of Chicago.

The resulting situation was highly disagreable to Anglo-American air transportation, for it was now within the power of either Government to bring economically intolerable conditions to bear on aircraft landings. Towards the end of 1945, for instance, the British Government informed the American Government that, although the entry of U. S. aircraft would be permitted, North Atlantic frequency should in future be limited to 14 return flights weekly with a maximum capacity of 500 seats, and that the fare should not be below $ 375.

This interim period was brought to a close with the conclusion of the Bermuda Agreement.

VI. The Bermuda Plan

Whatever one may wish to say against the individual decisions of the Bermuda Plan, it must be conceded that it is a big step forward. It is not so much the allocation of routes and decisions concerning frequency and capacity which count. Important is the spirit of the agreement: *the peaceful renunciation of sovereign rights by both parties.* Important too is that for the first time both States agreed voluntarily to submit their differences to the judgement of PICAO (Annex, II) and to comply with the rates fixed by IATA (Annex, II). IATA has no recognised identity under the Law of Nations. It is nothing else than a private grouping of all the same a considerable number of international carriers. One must be acquainted with the superior attitude with which sovereign States are accustomed to look down upon international private organisations, and the small importance diplomats attach to even the largest employers' and trade unions. Only then can one fully appreciate what was attained at Bermuda.

When compared with the "Five Freedoms", the advantages of the Bermuda Agreement manifest themselves strongly. The Transport Agreement certainly embraced a wider field; it was more "generous". In contrast, the Bermuda Plan limits the rights of contracting parties. It allocates carriers definite routes and stipulates landings at specified airports (Annex, III). It demands that available air transport facilities bear a close relationship to public requirements (Final Act, Paragraphs 3 and 6). It agrees that there be fair and equal opportunity afforded both parties (Final Act, Paragraph 4), and that capacity on intercontinental operations be related to the traffic requirements of the areas through which the carrier passes, after taking account of local and regional services (Final Act, Paragraph 6c). But, it is precisely these limitations which make the Bermuda Plan readily adaptable to practical conditions. The "Five Freedoms" were the formulation of an ideal. They were broadly conceived, disregarding small, every-day worries. And for this reason they were condemned, from the moment of their being set down on paper, to remain in theory.

Again, the Bermuda plan is reproached of embodying insufficient realism, of offering grounds for misunderstandings and presenting contradictory stipulations. The two parties find it particularly difficult to agree on whether the conditions governing capacity and frequencies are sufficiently clear.

Contradictory interpretations by British and Americans are effectively to be found. President Truman, in a special White House statement on February 26th, 1946, expressing his satisfaction with the Agreement, states:

"Under Bermuda Agreement there will be no control of frequencies, and no control of so-called Fifth Freedom rights on trunk routes operated primarily for through service. It gives to the airline operators the great opportunity of using their initiative and enterprise in developing air transportation over great areas of the world's surface."

Two days later, in a debate on the Bermuda Agreement in the House of Lords, Lord Swinton said:

"The Agreement, as I understand it, that there shall be a fair chance for both, means that each will be able, or ought to be in a position to put on enough planes, on this load factor principle, to carry half the traffic. That must mean, if it is to be carried out, that the United States will reduce their number of aircraft as we increase our number of aircraft. If not, we can get our share of the traffic only by putting on a large number of planes, while the United States' number of planes remains unreduced. In that event, it means that there would be, in fact, more planes operating than the traffic would justify, and that completely knocks the bottom out of the earlier provision that the amount of capacity shall be related to the amount of traffic."

In reply, the Government spokesman said:

"As he (Lord Swinton) said, quite correctly, so far as that is concerned the United States have a great start over ourselves, but I think that Paragraphs 4 and 5 to which he referred, quite fairly cover the point. It is perfectly evident that as things develop in the course of time, the tribunal which will be set up to consider disputes or questions will be able to adjudicate on the difficulties as they arise."

It is in the Truman/Swinton difference of interpretation that the main complaint of insufficient clarity seems to lie. Apart from this, there are series of small items, finding their root in U. S. national law and hence not directly bearing on our point, which concern themselves with the question of whether the President may officially approve the Agreement with or without the assent of the Senate.

It is our opinion that the British interpretation, in view of the clear text of the Agreement, is correct. Paragraph 6 of the Final Act is as follows:

It is the understanding of both Governments that services provided by a designated air carrier under the Agreement and its Annex shall retain as their primary objective the provision of capacity adequate to the traffic demands between the country of which such air carrier is a national and the country of ultimate destination of the traffic. The right to embark or disembark on such services international traffic destined for and coming from third countries at a point or points on the routes specified in the Annex to the Agreement shall be applied in accordance with the general principles of orderly development to which Governments subscribe and shall be subject to the general principle that capacity should be related:

a) to traffic requirements between the country of origin and the countries of destination;

b) to the requirements of through airline operation; and

c) to the traffic requirements of the area through which the airline passes after taking account of local and regional services.

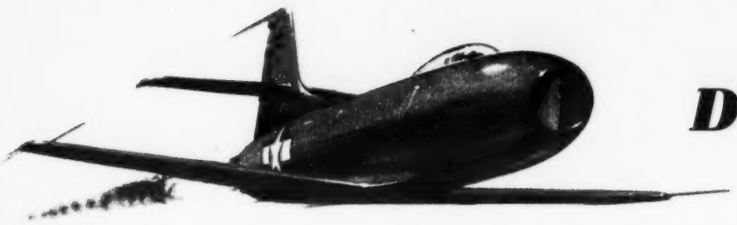
And Paragraph 4 of the Final Act:

That there be a fair and equal opportunity for the carriers of the two nations to operate on any route between their respective territories (as defined in the Agreement) covered by the Agreement and its Annex.

These sentences leave no room for query as to whether the matters of capacity and frequency have been settled. All that remains to be questioned is whether the competency of PICAO as tribunal extends to these objects, or whether the text of the Agreement infers PICAO's judgment in cases of fare disputes only.

One is, moreover, perfectly justified in pointing out that PICAO's verdicts in such instances are in no way binding and that compliance thereto is solely contingent upon the good or bad will of the States involved. But this brings us back to where we started, and it only remains to repeat what was already said earlier on:

Let us be glad that a way has been found at all by which the sovereignty of the States can be limited a little to the benefit of civil aviation. And if the Bermuda Plan, as pattern for a multilateral agreement, is not complete, this should represent no obstacle towards developing it accordingly. The logical inference of a "pattern" is a first step towards a "finished product". It is a foregone conclusion that the intermediate process will entail certain modification. *Dr. E. A. He.*



Douglas "Skystreak"

Already in 1945 it was recognised in the United States that neither the State-owned nor the private institutes for aeronautical research could be in a position, with the existing wind tunnel facilities, to supply within reasonable time the scientific and constructional data required by the aircraft constructor for the design of supersonic aeroplanes. The provision of new and more powerful high-speed wind tunnels could not be made simply from one day to the other. Consequently, the Forces' administrations and the aviation industry, finding themselves compelled to turn to other sources to acquire the indispensable knowledge for an attack on the sonic barrier, placed contracts with various aircraft manufacturers to design high-speed aeroplanes for research purposes. These aircraft, of which that built for the U. S. Army Air Forces by Bell Aircraft Corp. was described in this magazine [1], are actually flying laboratories. Fitted with an elaborate range of test equipment, their purpose is to investigate the aerodynamic influences occurring in the sonic speed region, which are so far mostly based on guesswork.

At the beginning of this year, the engineers of the Douglas Aircraft Co. were able to unveil the completed prototype of their *Douglas D-558* "*Skystreak*" to the public at the firm's El Segundo plant in California.

Its power plant is America's biggest jet-propulsion engine, the *TG-180* turbo-jet built by *General Electric*. Besides its 500 lbs. of research and measuring equipment, the "Skystreak" can carry enough fuel to enable it to return to base after short horizontal flights. With this load it attains a gross weight of 9,750 lbs., so that, with a wing area of 150 sq. ft., the wing loading at take-off works out at 65 lb./sq. ft.; for longer flights, additional wing tip tanks of 50 U. S. gals. each can be fitted, resulting in a wing loading increase of 4.1 lb./sq. ft. The

[1] "Interavia, Review of World Aviation", No 8/9, Nov./Dec., 1946, P. 74.

wing loading for landing is fixed at a maximum of 56 lb./sq. ft., which corresponds to a weight of 8,350 lbs.

The research equipment was designed and installed in collaboration with the National Advisory Committee for Aeronautics, and is to measure the air pressure at over four hundred points of the wing, fuselage and tailplane. All leads from these points are connected to an automatic recording apparatus situated aft of the pilot's seat, so that the pilot has no need to concern himself with it. The same applies to the equipment for measuring the complete load, with strain gauges connected to links located at three wing attaching points and at three tail attaching points.

In view of the relatively small radius of curvature, the application of magnesium alloys to the fuselage construction made it possible to build a monocoque type without incorporating stringers. Though the weight factor alone might not have warranted the use of magnesium alloys, this was all the same necessary in order to provide a completely free chamber to house the power plant. Besides resulting in a much stronger fuselage skin, this method also provided an exceptionally regular outer surface. An aluminium alloy was selected for the nose, cockpit and air intake ducts, the latter extending from the nose and passing either side of the cockpit to the power plant. An intricate problem was to find space in the wing, necessarily very thin in view of the high speed, for the particularly flat high-pressure landing wheels. Also due to the thinness of the airfoil, the aileron balance weights had to be made of a tungsten alloy, lead being of too low density.

The question of an effective and safe pilot ejection system was no simple matter to solve. In view of the speeds expected of the " Skystreak ", the conventional construction was considered inadequate. It was finally decided to divide the fuselage aft of the pilot's seat, so that, in a emergency, the entire nose and cockpit could be jettisoned by explosion. Once the speed has diminished during the drop to earth, the pilot can eject himself backwards and effect a normal parachute descent.

The strength limits of the " Skystreak " are about 60 percent higher than in high-speed fighters or bombers hitherto built. As assurance against overstrain on entering the sonic region, the design is based on an applied loading factor of 12 G and a rupturing load factor of 18 G.

The fuel supply, 230 U. S. gals., is contained in chambers between the spars and wing roots. The afore-mentioned wing tanks, each holding 50 U. S. gals., can be jettisoned by explosion in order to avoid any danger of damaging the tail assembly even at very high speeds.

The cockpit pressurisation system can maintain sea level pressure up to 8,000 ft, that of 8,000 ft. up to 22,000 ft, and above this, a differential pressure of 4 lb./sq. in.

The main characteristics of the " Skystreak " [1] are : span, 25 ft. ; length, 35 ft. $^1/_2$ in. ; height, 12 ft. 1 $^1/_2$ in. ; wing area, 150 sq. ft. ; aspect ratio, 4.17 ; gross weight, 9,750 lbs. ; wing loading, 65 lb./sq. ft.

Bi.

[1] " Interavia, Review of World Aviation ", No 2, Feb., 1947, P. 57.

FIRE ON BOARD!

On February 19th a four-engined "Constellation" of Air France, on its scheduled New York-Paris Atlantic run, sent out an SOS from a point some 600 miles distant from the coast. Despite the failure of both starboard engines, the crew had managed to keep the machine in the air and land it safely in Casablanca without any harm befalling the passengers or load.

The following report is an extract from the accounts sketched by the Captain and radio operators of the damaged airliner, and is intended to describe this dramatic flight in a simple manner without undue exaggeration. The whole story bears testimony to both the airworthiness of the aeroplane and to the high efficiency of French trans-Atlantic crews.

36° 45' Northern Latitude.

Notwithstanding a fire outbreak, the crew of a French trans-Atlantic airliner completed its scheduled New York—Paris flight.

(Daily press report.)

F-BAZC

Lockheed "Constellation" L. 049 No. 2074.
Heading 61/62 — Air France.
Take-off New York 18 February 19 h 20 GMT.
Landing Bermuda at 21 h 55 — Take-off 01 h 52 GMT.
Landing Lagens (Azores) at 11 h 30 — Take-off 14 h 17 GMT.

Crew.

Captain and Pilot : Charles Lechevalier.
Co-Pilot : Henri Betiaux ; second co-pilot : Henri Ballereau.
Radio operators : Etienne Nemes and Max Thomas.
Engineers : Jean-Marie-François Vincent and Roland Richard.
Stewards : Lucien Boudet and Jean Spiess.
Hostess : Monique Poulet.

Passengers.

Mrs. Georgette Chataignier, Mrs. Gladys Flori, Norman Reader, Maurice Saucourt, Raoul Salze and Marcel Voyer.

Load.

440 lbs. of luggage ; 4,993 lbs. of freight and mail, including 4,548 lbs. of diplomatic mail (copies of satellite Peace Treaties from Washington).

Take-off from New York on Februray 18th. Previous check of radio equipment : O. K. Take-off, 19 h 20 GMT. Landing at Bermuda, 21 h 55 GMT. VHF radio breaks down at landing, Nemes takes it to Air Transport Command workshop. Nobody acquainted with this equipment, and no test bench available ; Nemes has no choice but to test the tubes. Still out of order after re-installation ; neither reception nor transmission. Antenna circuit presumably broken during repair to automatic pilot at New York (after radio check). This is not serious as there are still three radio sets available ; the Captain decides to continue the flight.

Take-off from Bermuda on February 19th at 01h 52 GMT, heading for Santa Maria, Azores. Radio communications satisfactory. Santa Maria Met. received at 9h 40 GMT on 3,993 Kc/s. Altitude, 400 ft. ; visibility, 3 miles ; 10/10 ths. cloud. 7-m.p.h. wind from S.E. Airfield below at 10h 05 GMT and landing order given at 10h 06 — 10h 17 counter-order : forbidden in view of bad visibility ; heading for alternate airport at *Lagens*. Runway below at 11h 06 ; ceiling, 800 ft. ; visibility, 8 miles ; landing, 11h 30 GMT.

As no reliable weather reports were available from Europe, the Captain decided to head for Casablanca, and designated Lisbon as alternate airport. Take-off from Lagens at 14h 17 GMT. Right after the take-off, the aircraft entered a high layer of thundery clouds, which considerably interfered with radio communications ; Casablanca and Biscarosse were called in vain. Contact with Casablanca CNO after leaving cloud barrier at 15h 45.

EXOR 5 92 F BAZC QAA CNCA 1810 GMT

As Nemes put this message through, stating a probable landing in Casablanca at 18h 10, he had no idea of the eventful hours which lay ahead of him and his comrades. Everything was normal ; altitude, 19,000 ft. Then suddenly there is a strong smell of burning in the cabin. The hostess and stewards conduct a fruitless search behind the seats for what is presumably a cigarette ; the passengers look around at each other, trying to conceal their anxiety. The radio operator is on all fours, looking for a possible short circuit. Nothing. The smell of burning gets stronger. A few seconds later their is an ear-splitting noise : an engine has caught fire—the drama begins. Lechevalier immediately throttles down all four engines and drops 3,600 ft. Flames shoot out through the cowling of the outboard engine on the starboard wing. Engineer Vincent endeavours to feather its airscrew. No success ; the control is definitely defective. He works the fire extinguisher ; his movements are steady and rapid ; each one is a fight against death. Vincent's cool headedness is amazing. "He excelled himself," Lechevalier said later, "he was just as steady as if practicing." The fire is out and the pilot throttles engines 1, 2 and 3 down to 1,500 H.P. each.

ZC ENGINE 4 CUT OUT. POSITION
15h 45 GMT 36° 45' N 19° 30' W.

Nemes sends this emergency call to Casablanca, whence it is immediately re-broadcasted to all stations and airports within the area involved. A general state of alarm ensues. For hours several hundred men in three continents over thousands of miles were anxiously following the crew's struggle.

At 16h 02 flames again spurt out of No. 4 engine ; the aircraft loses more height, pierces further cloud banks and assumes a horizontal course again at 7,000 ft. Vincent tries time

36° 45' N., 19° 30' W. The Captain of the "Constellation" F-BAZC indicates on the map where the first engine mishap occurred.

The pilot's hands are hard on the wheel...

and time again to feather the airscrew. No effect whatsoever ; the blades will not obey. And now the inboard engine on the starboard side begins to work unevenly.

At 16h 07, No. 3 engines also has to be cut out, and Nemes sends out his first SOS :

ZC FLYING ON TWO ENGINES PORT SIDE PLEASE SEND AIR SEA RESCUE

The passengers are calm. From the cabin they could see the burning engine, and know that their lives are in danger ; the voice of the Captain and the coolness of the crew give them confidence. Life-jackets are distributed and the hostess sees to the safety belts. Each crew member is at his station.

Air speed : 140 m.p.h. Lechevalier, his hands hard on the wheel, pits his wits and will against the recalcitrant airliner ; engines 1 and 2 do all they can to throw it off course. At 16h 10 engine No. 3 is started again. Still no success in feathering the outboard airscrew. Altitude, below 200 ft. Beneath a dull grey sky was a raging sea ; huge, froth-capped waves were to be seen from the cabin windows. " Never in my life did the sea ever seem to come up so quickly, " Lechevalier said later. " And we were still 600 miles from Casablanca. An emergency landing on water ? Not a chance in a sea like that. There's nothing else than for you to stick it out, old girl ! Giddup then ! " This call is taken up by the whole crew.

At 16h 43, engine No. 4 is again in flames ; its airscrew is windmilling madly. The hub, ground out of shape, scrapes the cowling with a screaming noise. Molten metal particles are projected, which ignite the leaking oil. A steward reports that the wing skin aft of No. 4 engine is severely buckled ; the intense heat had caused critical deformations, and a new danger had arisen : the air impact could rip off portions of the skin...

At 16h 55, Lagens and Port-Lyauthey report that the rescue aircraft has taken off. The Captain continues to clip the waves for another half-hour. The navigator cannot obtain a fix, the aircraft being completely out of equilibrium.

At 17h 20, a tramp steamer is sighted. It must be SWAJ but no radio contact can be made. Will Lechevalier attempt an emergency landing ? Perhaps that all are not fully aware of his dilemma : Should he try to save the passengers by an emergency landing, in face of all the possible consequences ? Should he continue the flight, notwithstanding the extreme hazards ahead ?—For him, there is but one answer : the ship must necessarily be airworthy on two engines.

At 17h 35, eighteen minutes after Casablanca had re-broadcasted the SOS, the airscrew of the right outboard engine, still windmilling and its hub glowing white hot, began to incline inwards. Suddenly it tears loose and brutally slices through all the right-hand cylinders of No. 3 engine and a good part of its airscrew. The entire airliner begins to shudder violently, and the right inboard engine catches fire—the fire extinguishers are empty. The situation was more than tragic : engine No. 3 runs wild and causes dangerous vibrations. Despite the valiant efforts of the Captain, the aircraft becomes off course. The engineer cuts the oil and fuel ducts to engine No. 3, and feathers the airscrew. Lechevalier orders all seats in the corridor leading to the main cabin to be removed ; there seems to be no hope of ever reaching the coast. The captain turns to his co-pilot : " Go to the aft of the aircraft, there's nothing more you can do to help here. " Betiaux doesn't budge : " I'm staying. " A simple answer, but characteristic of the crew's team spirit. " A bond of friendship sprang up between us from that moment on, " Lechevalier said later.

The artificial horizon is defective. The pilot is thrown on his own resources. As long as the light permits, the aircraft can maintain a reasonable course. But dusk is rapidly setting in.

At 17h 45 the first radio contact is established between F-BAZC and the PBY " Catalina " rushing to the rescue.

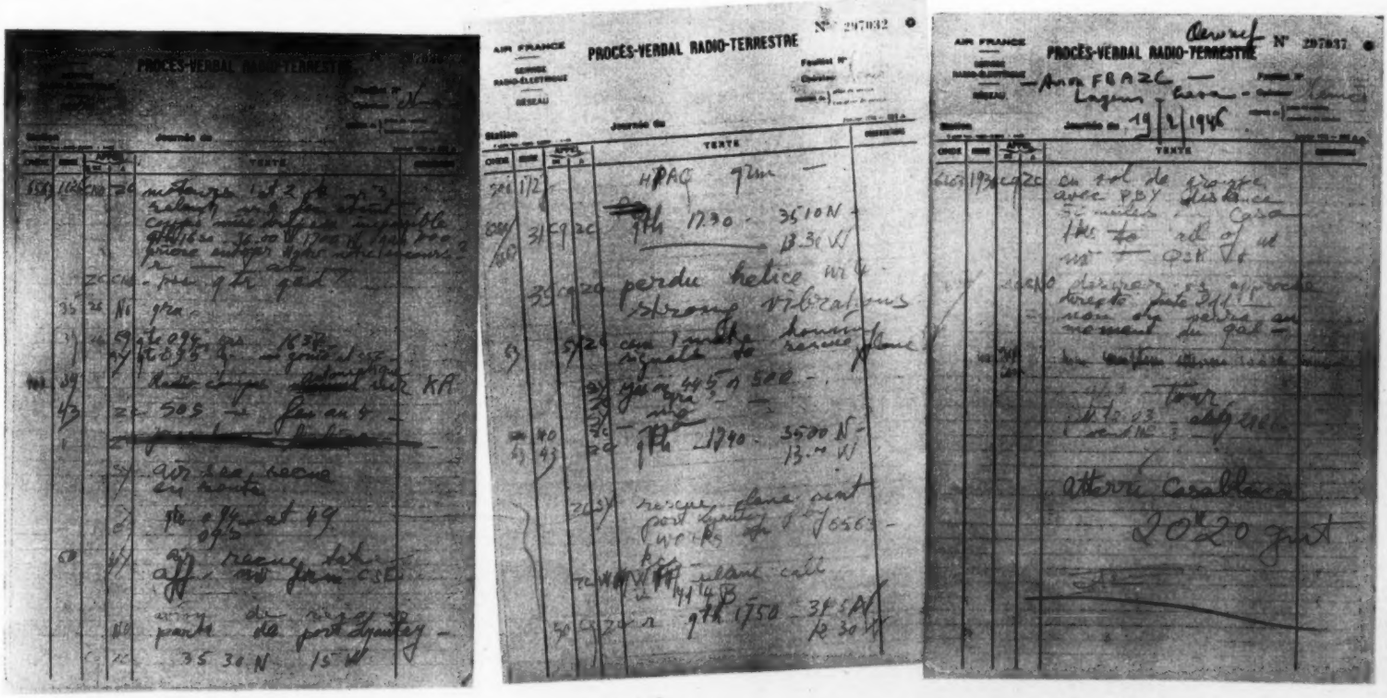
The knowledge that help is under way brings a faint ray of hope to the occupants. And a few minutes later Lechevalier perceives the rescue craft's position lights. It is now easier to steer the airliner, as the red and green lights of the flying-boat serve as horizon.

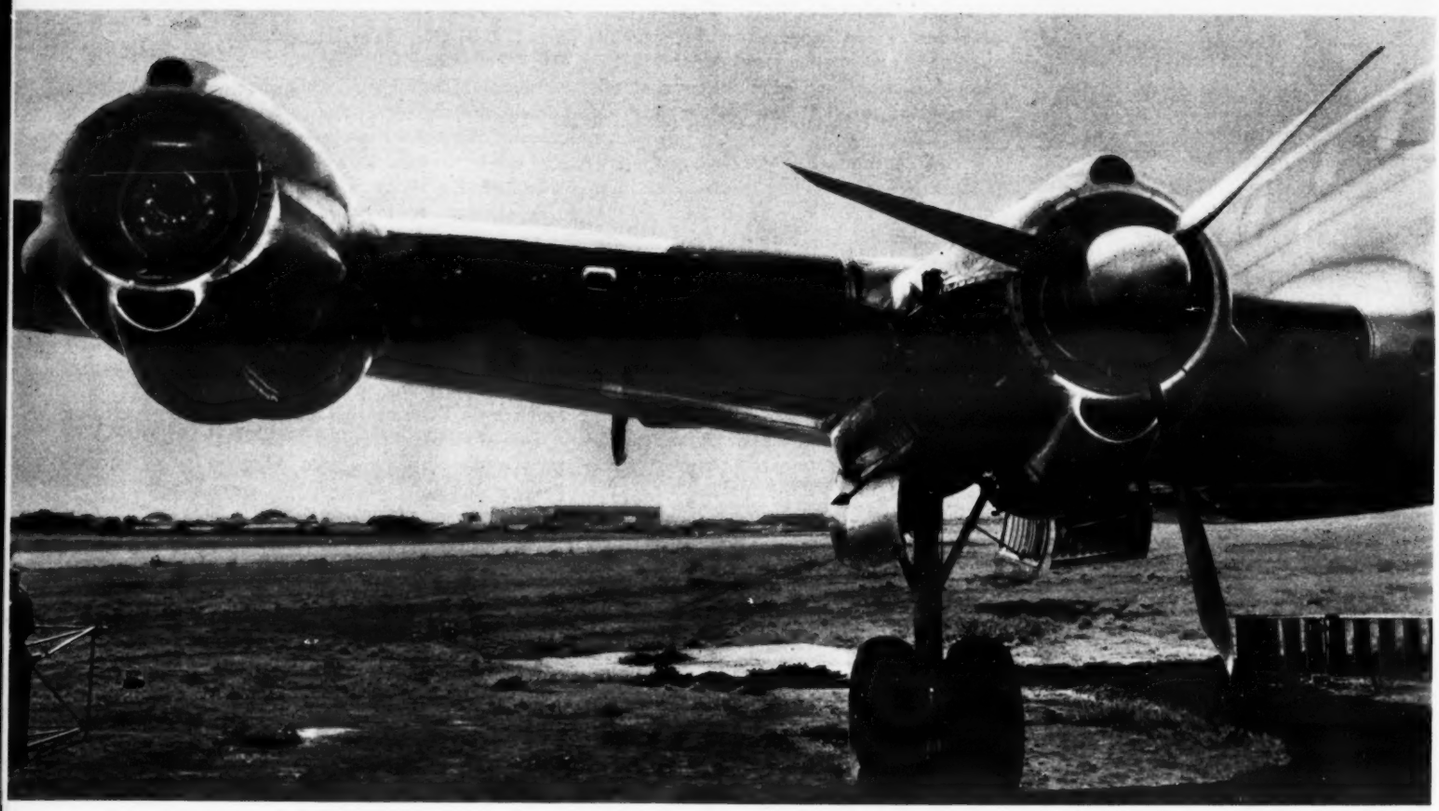
At 19h 25 the first oral connection is made with Casablanca on 6,440 Kc/s. The human voice is encouragingly significant of land ahead. Then a second aircraft is sighted : it is a " Flying Fortress " flying 3,000 ft. above them, ready, should the need arise, to drop a lifeboat.

A last radio message in morse :

50 MILES FROM CASABLANCA WQRS — DISTRESS TRIP TERMINATED

The radio operator's log book shows the SOS signals — and finally the happy landing at Casablanca.





The starboard wing of the Lockheed " Constellation " F-BAZC with the two damaged engines. The airscrew of engine No. 4 had ripped off and sliced into engine No. 3.

The F-BAZC is saved ! And with a sigh of relief, Lechevalier spots the Casablanca identity beacon.

Nemes announces their arrival to the airport tower :

ZC QAA CNCA 20h 20"

At 20h 10 they are over the lights of the city, and the runway is brilliantly lit up before them.

By order of the Captain, the hostess places all passengers at the rear of the cabin and bolsters them up with every available cushion in preparation for an eventual hard landing.

At 20h 15 they are over the runway. Betiaux works the hand pump to lower the undercarriage, but only two of the three signals light up : the starboard wheel refuses to budge. Are the pressure lines broken ?

Should Lechevalier make a belly-landing and severely crack up the aircraft ? " I haven't fought this far to rip the machine's belly open. Nothing doing : Giddup, old girl ! " Round the field again. Betiaux pumps feverishly and after an eternity, of five minutes, he gets the better of the unruly starboard wheel. The runway is approached again at 20h 20 ; speed is 150 m.p.h. There is no question of lowering the flaps ; the manual process is far too long and, in the event of a mistimed landing, would entail further dangers. The runway lights are approaching at an unbelievable speed.

In a steady voice, Betiaux reads off the speedometer : 149... 150... 155... 153... 149... 147... and the ship touches down. The shock is not too violent. Unfortunately, the nose-wheel is blocked and Lechevalier cannot keep to the runway. He deviates two or three degrees and makes for the grass at high speed. He exerts every ounce of his strength on the brakes ; dipping her nose violently, " Constellation " F-BAZC comes to an abrupt halt. The adventure is over with.

The whole airport is in an uproar. Fire engines, ambulances and a crowd of people all surge towards the aircraft and its crew. A fireman is already preparing his hose... Lechevalier is on *terra firma,* viewing the damage to the engines.

Charles Lechevalier, Captain of the damaged Air France airliner, tells the story of the unforgettable hours over the high seas.

ZC CNCA REPORT CAPTAIN F-BAZC
BREAKAGE IN PITCH CONTROL OF AIRSCREW ENGINE FOUR ON FIRE AND CANNOT FEATHER — FIRST EXTINGUISHER PUTS OUT FIRE TO OIL AND GAS — ENGINE FOUR CUT OUT — NEW FIRE OUTBREAK ALSO EXTINGUISHED — ENGINE THREE SHOWING SAME SYMPTOMS — WINDMILLING AIRSCREW FOUR DETACHES AND CUTS THROUGH ENGINE THREE — VIOLENT VIBRATIONS — AIRSCREW THREE FEATHERED — FLY TEN MINUTES ON ENGINES TWO THREE AND METO POWER — THEN EACH THOUSAND TWO FIFTY HP — HOLD ALTITUDE THREE HOURS — SOS BURNING ENGINE THREE — SECOND SOS NEW FIRE ENGINE FOUR — THIRD SOS LOSS AIRSCREW FOUR AND CUT OUT ENGINE THREE DUE VIBRATIONS AND OIL LEAKAGE — ACCOMPANIED ONE HOUR BY RESCUE AIRCRAFT — 2021 LANDED SAFE CASABLANCA.

LECHEVALIER.

Charles Lechevalier, 43 years old, has flown for 25 years and is one of the few Air France pilots who can boast more than two million miles flown. Member of a bombing squadron in 1922, he joined the Latécoère airline in 1924, which later changed its name to Aéropostale. He transferred to Air Union in 1933 and to Air France when it was founded in 1934. After flying the Paris-Dakar route he was transferred to the South Atlantic network. During the last war he was firstly in charge of testing American equipment and then, going to England, joined as a Ferry Command pilot, delivering aircraft between Britain and Canada.

On July 1st, 1946, Air France selected him to captain the inaugural Paris-New York crossing.

A New Method for Joining Light Metals

By A. von ZEERLEDER (Research Institute of S. A. pour l'Industrie de l'Aluminium, Chippis, Switzerland)

In aircraft construction the methods of joining metals in general, and light metals in particular, are : riveting, the more recent system of spot welding, and screws for dismountable joints. With increasing speeds, the demand for entirely smooth outer surfaces comes evermore to the foreground. This is best realised by means of such joining methods as welding, soldering and glueing, but, in view of the loss in strength which would occur in age-hardened aluminium alloys, welding and soldering are clearly unsuitable. On the other hand, glueing does not offer sufficient guarantee of strength. Hence, it is not to be wondered at that, notably in the field of aircraft construction, the desire has long since been expressed for a method of joining metals at not too high temperatures. Investigation reveals that patented systems of joining metals by means of plastics date back as far as 1918, and that today the patent records feature well over 100 different processes in this field, whereby, apart from leading metallurgical and aircraft firms, a good number of the inventions originate from organic chemistry and plastics concerns.

The demands placed upon an ideal joining system in aircraft construction are manifold. The primary requirement is a high degree of strength under conditions of either constant or varying tensile and bending stresses at temperatures ranging from —60° F. to +160° F. In addition, the joint should neither be loosened nor corroded by humidity influences, sea water, oil, grease, or even petrol or such fuel mixtures as may enter into contact with it. Of a special importance is that it be indifferent to ageing, which frequently causes plastics to become brittle. As in the case of welding and soldering, it also occurs that application of even moderately high temperatures over prolonged periods impairs the strength characteristics of refined alloys. For this reason the curing temperature of the plastics adhesive should under no circumstances be above 392° F., this in order to avoid any possible detriment to the hardening effect of the thermal treatment of light metals. The utilisation of plastics for joints should involve maximum simplicity and require no particular auxiliary mediums. For a long time, the characteristic of plastics to emit volatile products whilst curing impeded their use as a means to join metals, for the reason that such volatile products cannot escape through the impermeable metal skin. The problem arose, therefore, to develop new types of plastics which could cure of their own accord (condensation or polymerisation) without emitting volatile products and not requiring the external application of other substances.

As already stated above, the system of joining metals by means of rubber is not new ; and it has also been shown, in more instances than one, that this system fails to meet the requirements of the aircraft industry. The same applies to chlorine rubber. Brittleness occurs at low temperatures and the adhesive powers diminish with rising temperatures. Meanwhile, the progress effected during recent years, not only in America and in England, but also in Switzerland, has opened new vistas ; and plastics now exist which make it possible to execute perfect joinings of light metals, either between themselves or then with other materials such as wood, glass wool, rubber, linoleum, in a simple manner which satisfies every demand put forth by the aircraft constructor. The censorship which applied during the war to neutral countries made an exchange of scientific information between nations almost impossible, so that research continued entirely independently in Great Britain and the United States on the one hand, in Switzerland on the other, and it is only now that comparisons may be drawn between the technical developments of the different nations.

Initially, adhesive products were developed on separate bases to suit each requirement, this either in fluid, viscous or solid form. They were sprayed, brushed or sprinkled on to the surface in question. The first plastics to be used technically for such joinings involved synthetic rubber. Then, a two-phase system was developed, whereby synthetic rubber was first sprayed on to the metal, after which a viscous plastics compound was applied by means of a brush. Finally, there were methods which used synthetic resins, applied in the form of thin strips to the surface involved. All these procedures required temperatures ranging between 250 and 430° F., and pressures of 5 to 21 atm. ; pressures of only 1 atm. were exceptional.

Thus it is plain to see that, besides temperatures between 250 and 430° F., all these adhesives require considerable pressure for curing. These processes are known under the registered trade marks of Metalbond [1]), Redux [2]), Cycleweld [3]), Cyclebond [4]), Pliobond [5]), and Plastilock 500 [6]). All the plastics products used in these systems require high temperatures and pressures for curing, thus entailing a serious drawback which manifests itself particularly in the case of large-scale assemblies. Based on fundamentally different concepts, research in Switzerland during the past years has resulted in the development of the *Araldite joining method* *. Araldite-" CIBA " [7]) is a synthetic

[1] Consolidated Vultee Aircraft Corp., [2] Aero Research Ltd., [3] [4] [5] Chrysler Corp./Goodyear, [6] Goodrich, [7] Ciba Ltd., Basle (its use as an adhesive for joining light metals was developed by CIBA in collaboration with S.A. pour l'Industrie de l'Aluminium).

* Cf. Preiswerk/von Zeerleder, Light Metals, Vol. 9, No. 102, P. 357-360 (1946).

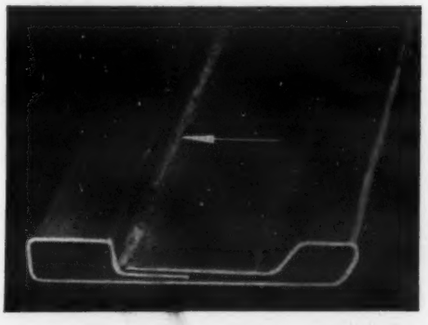


Fig. 1:
Joining with Araldite of two chamfered sections of sheet metal.

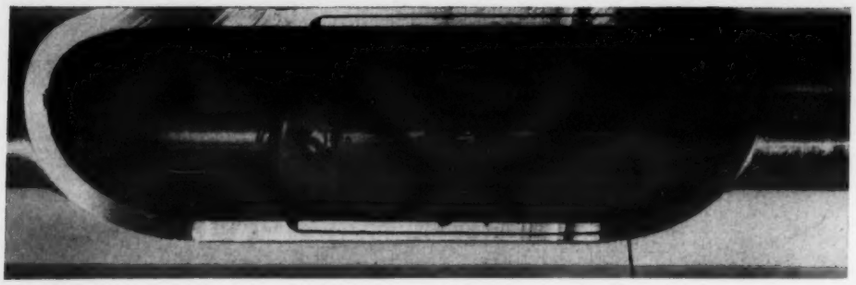


Fig. 2 : Joining of two pipes with Araldite.

resin which polymerises of its own accord under thermal influence, and effects a perfect joining of metals with metals, or with other materials, without pressure.

Fig. 1 shows the joining of two chamfered sections of sheet metal by means of Araldite. All that is necessary is to sprinkle Araldite powder, Type I, into the entry marked with an arrow, and then to place the entire assembly for 30 min. in an oven at 374° F. for curing. Attaining a high degree of fluidity at this temperature, the Araldite introduces itself between the two sheets by means of capillarity, thus joining them perfectly as it hardens. This method of joining clearly shows the advantage of a curing action without pressure. Fig. 2 shows a joining of two pipes without any rugosity whatsoever, either internally or externally.

In view of the fact that the search for suitable adhesives to join light metals has now been going on for over a quarter of a century, it is naturally surprising to find that satisfactory results were only obtained during the past few years. Again, it must not be forgotten that the theory of the adhesive force is as yet based on entirely inadequate concepts. Two kinds of force are differentiated where materials are joined, namely, cohesion and adhesion. Cohesion indicates the union of materials of the same kind, adhesion the union of different materials. According to present-day available knowledge, three kinds of force play a rôle in the adhesion of organic materials to metals. The first is the primary chemical binding between the metal or its superficial oxide, and the organic matter. This binding entails an exceptionally favourable effect in the case of aluminium where the layer of oxide is solidly anchored in the metal. A less effective joining, likewise a chemical one, is involved in the second force, which is with the help of the so-called secondary valences of the organic matter. It is with the help of these valences, for instance, that the adhesion of nylon to glass can be explained, which is characterised by feeble resistance. The third, usually rather weak phase of the adhesion is the purely mechanical anchoring of the plastics in the surface of the metal, which calls for an initial roughening of the latter. In a joining of materials applicable to aircraft construction, it is only the first adhesive force which can meet with the above-mentioned requirements. The adhesives in question stick just as well to a highly-polished surface as to a rough one—provided that these are entirely free from grease—so that reference to a chemical bonding is fully justified. It must also be mentioned that this bonding features especially high strength in the case of trivalent metals, such as chromium, iron and aluminium.

The working methods differ according to the materials to be joined and the types of plastics selected. Combinations of different plastics are frequently used, in which instances the components are applied one above the other on to the surface to be treated. There are other cases were the plastics are dissolved and the solution brushed or sprayed on to the surface. These methods, however, require careful pre-heating in order that the solvent be eliminated prior to the binding action. The least residue of solvent can impair the strength of a plastics joint. A reliable method is to apply a synthetic resin of the kind supplied in sticks which liquify around 212° F., to a pre-heated surface, similar to the soldering process. In assembly-line production, an extremely simple and particularly interesting system is to use a powdered synthetic resin, which liquifies on contact with a pre-heated surface, distributes itself evenly, and penetrates by capillarity into the crevices. Such synthetic resins can, moreover, be dyed to any colour to make the joint areas match the rest of the metal. In this manner, it is a frequent practice to add powdered aluminium to Araldite, which gives it a metallic appearance without reducing its adhesive qualities.

In order to obtain an idea of the strength of such joints, it is first necessary to establish certain comparable data. Whilst the strength of the metal is usually expressed in lb./sq.in., in this case it is not only necessary to consider the section of the metals to be joined, but also the size of the contacting surfaces (overlap) receiving the adhesive. As in the case of soldering, an increase of the contacting area can, to a certain extent, result in an increase in strength. Consequently, comparisons should only be made between joinings of the same nature. For practical research, test strips of 1 in. (25 mm) width with ½ in. (13 mm) overlap are generally used. As can be seen in Fig. 3, the stress passes gradually from one metal strip to the other. Whereas the upper strip on the left-hand side features the maximum tensile stress, the lower strip is subjected to almost no load whatsoever ; inversely, the lower strip on the right-hand side is supporting the entire tensile stress. The result is that not only tensile stresses are exerted at both ends of the joint, but, as a result of the elastic expansion of one of the strips, noticeable shearing stresses are also ascertainable. In order to absorb these shearing stresses, the adhesive must feature a certain elasticity, which characteristic is strongly manifested by Araldite. It may be seen from Fig. 4 that, in the case of thin strips, bending stresses are exerted at the joints, thereby diminishing the strength.

An increase in thickness of the sheets results in a corresponding diminution of the elastic expansion and of the bending stresses. An increase in overlap brings about an increase in the displacement at their extremities. Hence, the most advantageous trans-

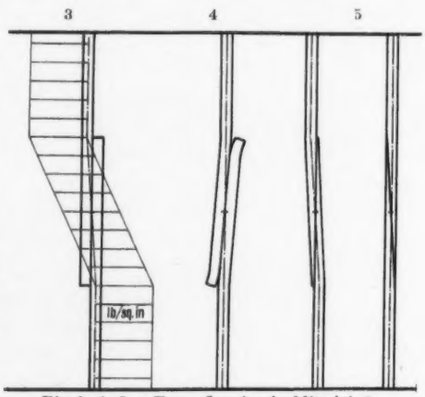
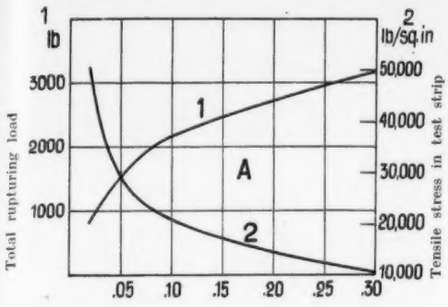


Fig 3, 4, 5 : Force flow in Araldite joints

mission of the stresses is attained, as is shown in Fig. 5, by a tapering towards the extremities of the parts to be joined. But, as this procedure entails additional manufacturing costs, it is renounced more often than not. Fig. 6 shows the total rupturing load and the tensile stresses on test strips of different thicknesses joined with Araldite. Fig. 7 and table 1 show temperature influence on the shear strength of both Araldite and Redux * joints. The decrease in strength is least in the case of Araldite, and it does not exceed 10% until after 10 minutes heating at 212° F. In contrast, other adhesives reveal the same degree of decrease in strength already at 158° F. The influences of various solvents on the shear strength of

* Light Metals, 1943, P. 22.



Test strips : Anticorodal B, 0.985 in. (25 mm) wide
Adhesive : Araldite type 1 Test temperature : 64.4° F.
Curing : 392° F. ; 40 min. Overlap : 0.512 in. (13 mm)

Fig. 6 :
Rupturing load and tensile strength in test strips joined with Araldite.

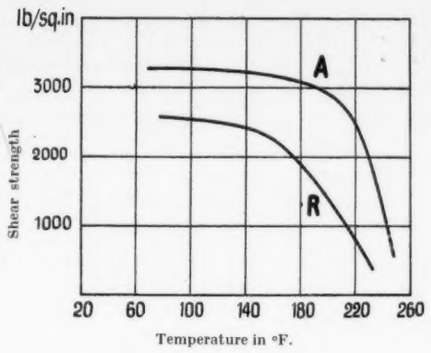


Fig. 7 :
Influence of temperature on the shear strength of Araldite (A) and Redux (R) joints.

that the separate parts join together well, and that no relative displacement takes place, it is best to block them into position, whereby a good result is obtained with clamps. There is no necessity to apply any high-pressure. Table 3 shows the influence of curing time and temperature on the strength of Araldite joints. It is seen that an increase in temperature reduces the time required for curing. For each temperature the permissible curing time extends over a definitive period ; as the temperature rises and accelerates the hardening action, this period becomes shorter. The best adhesion is attained at temperatures between 320 and

Table 1

Strength at high temperatures of an Araldite joint

Temperature °F	Shear streagth lb./sq.in.	
68	3,270	
104	3,130	
140	3,130	
176	3,130	Average of
194	2,990	six tests
212	2,700	
230	1,420	
248	1,000	

Test strips : Avional, 1 in. (25 mm) wide
Overlap : ½ in. (13 mm)
Adhesive : ARALDITE TYPE 1
Curing : 392°F ; 40 min.
Joining area : 10 min. at test temp. before loading ; prolonged heating

Table 2

Resistance of Araldite joints to water and solvents

Carrier or solvent	Duration of test days	Shear strength lb./sq.in.
—	—	3,410
Water at 68°F.	10	3,130
Water at 68°F.	10	3,130
Benzine	30	3,410
Acetone	10	3,270
Methanol	10	3,130
Benzol	10	2,840
Water at 194°F.	10	2,270
Water at 194°F.	30	1,990

Test strips : Avional, 1 in. (25 mm) wide
Overlap : ½ in. (13 mm)
Adhesive : ARALDITE TYPE 1
Curing : 392°F ; 40 min.
The test strips were tried out about ½ hour after extraction from the baths. They were only wiped externally.

Table 3

Influence of hardening temperature and duration on the strength of Araldite joints

Curing temperature °F.	Minimum curing time	Optimum curing time	Maximum curing time
266	24 h		
284	15 h		
302	9 h		
This zone is to be recommended			
320	5 h	10 h	2 days
338	3 h	6 h	1 day
356	2 h	3 h	15 h
374	1 h	2 h	8 h
392	40 min.	1 h	5 h
410	30 min.	50 min.	3 h
428	20 min.	30-40 min.	100 min.

Araldite are compared in table 2. One generally reckons with a shear strength of 2,200 to 3,600 lb./sq.in. at room temperature. This strength decreases inversely as the temperature rises.

The purpose now is to describe the technical application of Araldite as an adhesive. First of all, care must be taken that the stress be as much as possible in the direction of the plane of adhesion, this because the notch bar strength of plastics joints is relatively feeble. The joint must be designed so as to present sufficient contact area, i.e., sufficient overlap. The surfaces must fit well together ; in tubular assemblies, for instance, the clearance should not exceed 0.008 in., otherwise capillary action will occur and the crevice will only partly be filled with plastics.

The surfaces to be joined are de-greased (e.g. with benzol, alcohol, methylated spirits or P3), carefully cleaned with a steel brush or steel wool, warmed to approx. 160 to 250° F. (until the resin melts on contact) and then coated with synthetic resin, laid together and hardened in an oven at temperatures between 266 and 428° F. To ensure

373 F. Temperatures above 392 F. impair the resin and cause a decrease in its adhesive power. Fig. 8 shows the relation between curing temperatures and curing times apply-

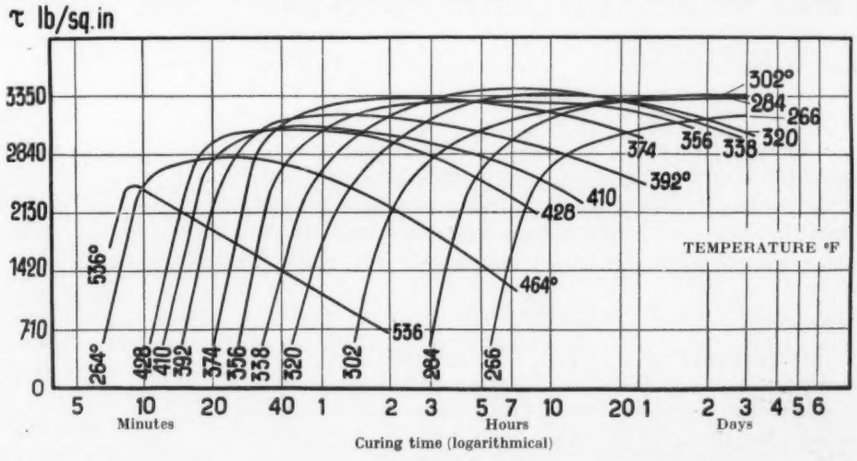


Fig. 8 : Adhesive strength in direction of plane of adhesion in Araldite joints of Anticorodal sheeting, in function of curing temperature and duration. Anticorodal A sheet strips, 0.0985 in. thick, 0.985 in. wide, with overlap of 0.630 in.

ing to Araldite, whereby the time is expressed logarithmically.

To obtain optimum strength of the joints, the overlaps indicated in column 3, table 4, should be observed. In this way the tensile strengths listed in column 5 will be attained and, in the joint, the correspondingly calculated adhesion (column 4).

All alloys do not lend themselves equally favourably to plastics joining. Heat decreases the strength of cold-drawn materials, whilst in alloys hardened at room temperature it causes a structural change which can ultimately lead the way for inter-crystalline failure. The alloys most suited to this type of joining are heat-treated types, or such alloys as Peraluman which can be used in either soft or semi-soft state. In the case of age-hardenable alloys the ageing is executed at the same time as the curing (polymerisation) of the plastics. As for optimum strength, practically the same durations and temperatures of hardening apply to both the alloy and the adhesive, the alloys listed in table 5 (Anticorodal B and Avional-S plated) lend themselves particularly well to this method.

Table 4

Strength of various alloys joined with Araldite

Alloy	Sheet thickness in.	Overlap in.	Adhesive strength in plane of adhesion lb./sq.in.	Tensile strength in sheet outside adhesion area lb./sq.in.
Peraluman-3	0.02	0.31	1,850	29,900
soft	0.04	0.59	1,850	28,500
	0.08	1.57	1,420	27,000
	0.12	1.97	1,420	24,200
	0.16	2.36	1,420	21,400
Anticorodal-B				
Original quality A	0.02	0.19	4,980	47,000
	0.04	0.59	3,130	47,000
	0.08	1.38	2,700	47,000
	0.12	2.36	2,280	47,000
	0.16	3.35	2,280	47,000
Avional-S plated	0.02	0.39	3,130	61,200
	0.04	0.79	2,990	61,200
	0.08	1.57	2,990	61,200

Thorough and systematic research reveals strength characteristics in Araldite which meet to a great extent the demands put forth by the aircraft constructor for a perfect and serviceable joining method. Hence, it can safely be predicted that plastics will find an ever wider application in the field of aircraft construction.

Table 5

Strength and composition of aluminium alloys

	% Cu.	% Si	% Mg	% Mn	Yield point under tension $\sigma 0.2$ lb./sq.in.	Tensile strength $\sigma\ 3$ lb./sq.in.	Expansion $\delta 5$ %	Expansion $\delta\ 10$ %	Brinell' hardness lb./sq.in.	Alternating bending strength $\sigma wb\ 20$ lb./sq.in.
Peraluman 3 soft	—	—	2-3	0-0.4	12,800-19,900	29,900-37,000	22-30	18-26	71,100- 92,400	12,800-15,600
Anticorodal B (cured)	—	0.5-1.5	0.5-1.0	0.2-1.0	38,400-54,000	45,500-59,700	12-20*	10-14*	128,000-171,000	12,100-13,500
Avional D hardened	3.5-5.0	0 -1.0	0.2-1.5	0.2-1.5	34,100-42,700	54,000-62,600	20-26	16-22	142,000-171,000	15,600-18,900
Avional-S plated hardened	—			—	55,500-62,600	66,800-72,500	12-16	10-14	185,000-213,000**	14,200-15,600

* In sections and tubes, the minimum value may be below 2%.
** Hardness of nucleus ; hardness of plating, 128,000 - 170,500 lb./sq.in.

PERFORMANCE CALCULATION FOR HELICOPTERS

By Walter Just, D. Sc. *

The rapid development of the helicopter during and since the last war has given rise to such interest that the prevailing dearth of related literature is generally regretted in interested circles. Whereas performance calculation for conventional aircraft is familiar to every aircraft constructor, this by no means applies to performance calculation for helicopters. In the following paragraphs, therefore, the fundaments of performance calculation for helicopters are presented ; and in a manner which is best suited to practical requirements. The main functional conditions are dealt with, namely, hovering, vertical and horizontal flight.

1. Hovering Flight

The calculation of the hovering flight condition is of particular importance as it is precisely the ability to remain stationary in the air that constitutes the helicopter's advantage over the conventional aircraft ; and it will be seen later that a helicopter requires more power hovering than in moderate forward flight. If calculation can prove that hovering is possible, then there exists the certainty that the helicopter's power will enable it to fly forwards at a reasonably high speed, of over 60 m.p.h.

A helicopter in hovering condition corresponds to the turning airscrew of a static aeroplane. Hence, it is the intention here to develop a slipstream theory and a rotor blade theory on the lines of of the propeller theories. Though the slipstream theory deals chiefly

* The following paper is an extract from works based on many years of experience which the author, at present engaged in France by SNCASE, was able to acquire whilst with the Focke-Achgelis firm.

SYMBOLS

Dimensions:

D	= Rotor diameter	(m)
R	= Rotor radius	(m)
r	= Radius at given point	(m)
r_o	= Jet nozzles to axis of rotation	(m)
x	= r/R	
F	= $D^2 \pi/4$ = Rotor disc area	(m^2)
t	= $t_o (1+px)$ = Blade chord at given point	(m)
$t_{0.7}$	= Chord at $x = 0.7$	(m)
h	= Rotor to ground	(m)

Forces:

G	= Gross weight	(kg)
S	= Rotor thrust	(kg)
P_D	= Jet thrust	(kg)
A	= Lift	(kg)
W	= Drag	(kg)
W_{Ro}	= Rotor drag	(kg)
W_s	= Rotor parasite drag	(kg)

Moments, Power, etc.:

M	= Torque moment	(mkg)
M_L	= » » due to air forces	(mkg)
M_D	= » » due to jet forces	(mkg)
M_{Co}	= » » due to Coriolis forces	(mkg)
N	= Power	(metric H.P.)
N_{Mo}	= Engine output	(metric H.P.)
N_{Ro}	= Rotor output	(metric H.P.)
N'	= Power	(mkg/sec)
N'_{tot}	= Total power	(mkg/sec)
N'_{eff}	= Effective power	(mkg/sec)

Speeds, Dynamic pressure:

v	= Speed (m/sec)
v_{res}	= Resultant speed at rotor blade (m/sec)
v_{str}	= Slipstream speed (m/sec)
w	= Speed of ascent (m/sec)
w_s	= Speed of descent (m/sec)
w_a	= Auxiliary axial slipstream speed (m/sec)
q	= Dynamic pressure (kg/m^2)
q_{str}	= Dynamic pressure in slipstream (kg/m^2)
U	= Blade rotative speed (m/sec)
n_{Ro}	= Rotor speed (r.p.m.)
ω	= Angular velocity of rotor (1/sec)
n_{Mo}	= Engine speed (r.p.m.)

Angle settings:

α	= Rotor angle of incidence
α_{eff}	= Effective angle of incidence at rotor blade
α_i	= Induced angle of incidence at rotor blade
ϑ	= $\vartheta_o + \vartheta_1 x + \vartheta_2/x$ = Rotor blade angle of incidence at given point
$\vartheta_{0,7}$	= Blade angle of incidence at $x = 0.7$ chord
β	= $a_o - a_1 \cos\psi - b_1 \sin\psi$ = Blade flapping angle

Efficiency:

ζ_L	= Performance factor for hovering
ζ_{LV}	= Power factor for horizontal flight
η_E	= Installation efficiency
η_G	= Gear efficiency + losses due to cooling blower and rear rotor
η_a	= Axial efficiency
η_t	= Tangential efficiency
η_{cw_p}	= Airfoil drag efficiency
η_s	= High speed efficiency

Coefficients:

c_a	= Lift coefficient
$\bar{c}_a$	= Mean coefficient for entire rotor blade
c'_{a_∞}	= Lift gradient
c_w	= Drag coefficient
c_{wp}	= Airfoil drag coefficient
c_{ws}	= f_{ws}/F = Helicopter drag coefficient
c_n	= Air force coefficient normal to plane of rotation
c_t	= Air force coefficient in plane of rotation (tangential)
c_n	= $\frac{S/F}{\varrho/2 v^2}$ = Load factor
k_n	= Thrust coefficient
k_d	= Torque moment coefficient
k_a	= Lift coefficient
k_w	= Drag coefficient
k_{ws}	= Parasite drag coefficient
λ	= v/U = Advance factor
σ_o	= $\frac{z \cdot t_0}{R \cdot \pi}$
$\sigma_{0.7}$	= $\frac{z \cdot t_{0.7}}{R \cdot \pi}$ = Disc density
δ	= Flow factor

Constants, etc.:

ϱ	= Air density ($kg\ sec^2/m^4$)
ϱ/ϱ_o	= Density ratio
A	= Blade root (without dimension)
B	= Blade tip (without dimension)
D_n	= Integration constant
D'_n	= » »
z	= Number of blades per rotor
f_{w_s}	= Parasite drag area (m^2)
$f_{w_s\,str.}$	= Drag area in slipstream (m^2)
Q	= Air mass flow per second (kg sec/m)

with the momenta and energies prevailing in the propeller stream, it is a simple matter to derive useful performance formulæ from it, and thus to obtain a relation between power and thrust. The rotor blade theory chiefly concerns the separate blades, but also takes the blade airfoil drag into account and bears accurately on the rotor as well as on its angular velocity, the latter not being determined by the slipstream theory.

Slipstream Theory.

The helicopter is imaginatively replaced by a porous circular disc whose characteristic is to accelerate the air in axial direction. Far forward of the disc the air speed is 0, and far aft thereof, it measures w_a (Fig. 1).

Hence, the speed in the rotor plane is, as can easily be demonstrated, the arithmetical mean between the speeds far forward and far aft of the rotor, thus $w_a/2$.

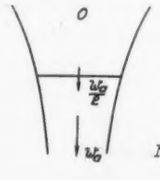


Fig. 1:
Notation to the Slipstream Theory.

With this, the per-second air-mass flow through the rotor disc area F measures:

(1) $$Q = \varrho F \frac{w_a}{2} \left[\frac{kg\ sec}{m}\right] \qquad \varrho = Air\ density \left[\frac{kg\ sec^2}{m^4}\right]$$

The rotor thrust is derived from the principle of momentum, whereby the thrust equals the air mass flow per second, Q, multiplied by the increase in speed, thus

(2) $$S = Q\,(w_a - 0) = \varrho F \frac{{w_a}^2}{2} \quad [kg]$$

The power is obtained from the difference between the kinetic energies per second fore and aft of the rotor, hence

(3) $$N' = \frac{Q}{2} {w_a}^2 - 0 = \varrho F \frac{{w_a}^3}{4} \quad \left[\frac{mkg}{sec}\right]$$

Combination of equations (2) and (3) (eliminating w_a) then yields the well-known Bendemann formula

(4) $$S = \sqrt[3]{2\varrho F N'^2} \quad [kg]$$

This formula indicates the amount of thrust obtainable without further losses. But in reality, however, there still remain the following losses which must be accounted for, namely, blade airfoil drag,

twist losses in the slipstream and irregular distribution of the speed $w_a/2$ over the entire rotor disc area F.

It must be pointed out that above, the speed $w_a/2$ was regarded as a natural constant, which condition is well supplied in good helicopters. Further, more accurate investigation has shown that a constant speed $w_a/2$ precisely represents the optimum. By grouping all the afore-mentioned losses in one performance factor, ζ_L, the following is obtained from equation (4) :

$$S = \sqrt[3]{2\varrho F\ (N'\zeta_L)^2} \qquad [kg] \tag{5}$$

For practical calculation purposes, the density ratio ϱ/ϱ_o and the power N in H.P. (metric) are introduced into equation (5), yielding

$$S = \sqrt[3]{\frac{\varrho}{\varrho_0} 1410\, F\, (N\,\zeta_L)^2} \qquad [kg] \tag{6}$$

A solution of this equation (6) in terms of N/S gives the following important relation between power and thrust for a rotor

$$\frac{N}{S} = \frac{1}{\zeta_L}\sqrt{\frac{S/F}{\varrho/\varrho_0 \cdot 1410}} \qquad \left[\frac{H.P.}{kg}\right] \tag{7}$$

This relation is represented graphically in Fig. 2 by the curve $w = 0$.

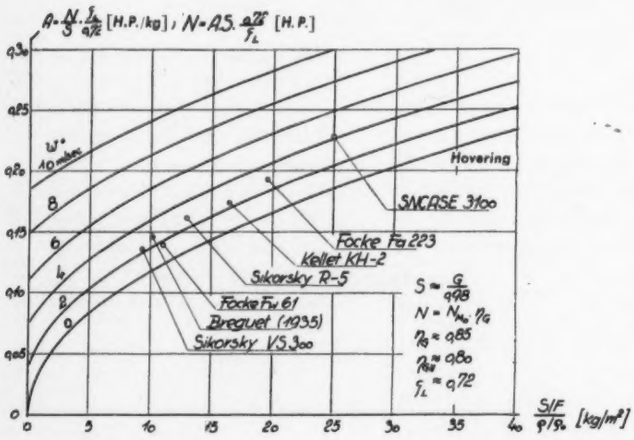


Fig. 2:
Power diagram for helicopters in hovering and vertical climb flight.
η_G without rear rotor; η_{GH} with rear rotor.

Hereby the following is to be observed. The power N signifies the power at the rotor given up by the engine. Losses in the reduction gearings and a certain deduction from the engine power to drive a cooling blower, rear rotor for torque compensation, etc., are accounted for in a factor η_G. Thus $N = N_{Mo} \cdot \eta_G$. The following losses may be admitted in first approximation : 3% for gearings, 12% for the blower and 7% for the anti-torque rotor ; test flights and calculation have shown the performance factor ζ_L approximately equal to 0.72. More precise data are to be found lower down.

As the aircraft parts situated in the rotor's slipstream create downward drag, thus negative lift, the rotor thrust must necessarily exceed the gross weight by this amount in order to make hovering possible. This negative lift is equal to the sum of the drag components, thus

$$W = f_{ws\,str} \cdot q_{str} \ ; \qquad f_{ws\,str} = \Sigma c_w \cdot f \ ; \qquad q_{str} = \frac{\varrho}{2} v_{str}^2$$

The slipstream speed may be determined from equation (2), so that

$$w_a = \sqrt{\frac{S/F}{\varrho/2}} = 4\sqrt{\frac{S/F}{\varrho/\varrho_0}} \qquad \left[\frac{m}{sec}\right] \tag{8}$$

The speed w_a is only attained at a certain distance aft of the rotor, about equal to the diameter of the rotor. On the other hand, the aircraft parts in question are situated much nearer. Assuming that the speed of the slipstream at this spot is about the average between that in the plane of rotation and far aft thereof, results in

$$v_{str} = 0.75\, w_a = 0.75\sqrt{\frac{S/F}{\varrho/2}}$$

so that the negative lift

$$W = f_{ws\,str} \cdot 0.56\,\frac{S}{F}$$

Therefore, the effective thrust, which in hovering flight is equal to the gross weight, then becomes

$$S_{eff} = S - W = S\eta_E \quad [kg] \ ; \qquad \eta_E = 1 - 0.56\,\frac{f_{ws\,str}}{F} \tag{9}$$

whereby η_E may be regarded as the installation efficiency. In good constructions, its value is of little influence, being of the order of $\eta_E = 0.98$.

For statistical considerations, which invariably furnish a good overall survey and are the surest fundament of every aerodynamical calculation, the helicopters built and projected may be represented in the above graph (Fig. 2), as is already the case with certain models. In this instance, the afore-mentioned approximate values are applied, i.e., gearing plus cooling blower, $\eta_G = 0.85$; gearing plus blower plus rear rotor, $\eta_G = 0.80$; $\eta_E = 0.98$.

The power in excess of that necessary for hovering flight, $w = 0$, is used for the vertical climb, as will be seen more precisely later. The decrease in air density with the altitude corresponds to an increase in disc loading S/F.

Rotor Blade Theory

The rotor blade theory takes into account the exact flow conditions applying to each individual rotor blade. Distinction is made between two theories. In the first theory, it is taken for granted that the air speed $w_a/2$ is of uniform value throughout the rotor plane, otherwise representing optimum conditions. This theory, forthwith designated as the δ = constant theory, is relatively simple and synoptical ; it furnishes sufficiently accurate results in cases where such a uniform speed of flow through the disc area is present, which prevails invariably is well-constructed helicopters. The second theory is the exact and much more complicated propeller theory ; as space forbids its inclusion in this article, may it suffice later to mention its numerical results for the purpose of comparison.

For development of the equations for the δ = constant theory, departure is made from a blade element (Fig. 3).

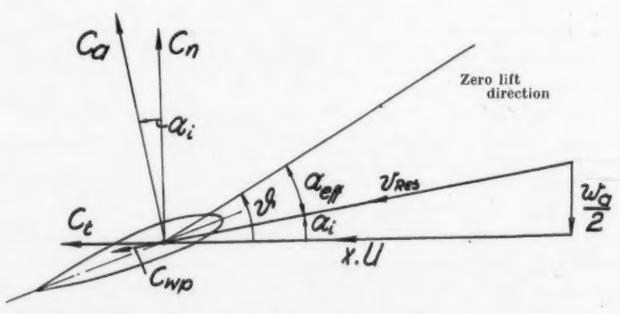


Fig. 3.
Flow conditions and forces reacting on a blade element

As a result of its rotation, the airfoil element situated at a distance $x = r/R$ from the axis, receives the air at a speed of $U \cdot x$, whereby U is the blade tip speed. With the penetration speed $w_a/2$ through the rotor disc, the resultant flow speed as applied to the element, v_{res}, is obtained. The lift c_a is perpendicular to v_{res}, and the airfoil drag c_{wp} lies in the direction of v_{res}. The rotor thrust is derived from the air force component c_n, perpendicular to the plane of rotation, and the torque moment from the air force component in the plane of rotation, c_t. Fig. 3 supplies

(10) $$c_n = c_a \cos \alpha_i - c_{wp} \sin a_i \approx c_a$$

(11) $$c_t = c_a \sin \alpha_i + c_{wp} \cos \alpha_i \approx c_a \cdot \alpha_i + c_{wp}$$

The thrust reacting on an element of chord t and width dr thus results in

$$dS = c_n \frac{\varrho}{2} v_{res}^2 t\, dr \approx c_a \frac{\varrho}{2} x^2 U^2 t\, dr$$

By calling the blade angle of incidence δ, thus the angle between the zero lift direction of the airfoil and the plane of rotation, the effective angle of incidence at the rotor blade is obtained :

(12) $$\alpha_{eff} = \vartheta - \alpha_i\,; \quad \alpha_i = \operatorname{arctg} \frac{w_a/2}{U \cdot x} \approx \frac{w_a/2}{U \cdot x} = -\frac{\delta}{x}\,;$$
$$\alpha_{eff} = \vartheta + \frac{\delta}{x} \qquad \delta = -\frac{w_a/2}{U} = \textit{Flow factor}$$

For the linear section of the c_a— α_{eff} curve, c_a may be made equal to $c'_{a\infty}\ \alpha_{eff}$, whereby $c'_{a\infty}$ represents the lift gradient which, in the case of a normal airfoil, is of the order of $c'_{a\infty} = 5.6$. Hence, the thrust element is

$$dS = c'_{a\infty} \frac{\varrho}{2} U^2 x^2 t \left(\vartheta + \frac{\delta}{x}\right) dr$$

For the blade chord t and the angle of the blade incidence ϑ, the following approximations may apply, by means of which all ranges of blade chord and incidence angle likely to occur in reality, may be expressed :

Blade chord at given point; $\quad t = t_0(1 + px)$

Blade angle of incidence at given point; $\quad \vartheta = \vartheta_0 + \vartheta_1 x + \vartheta_2/x$

The total thrust for z blades is thus obtained by integrating along the blade from $x = A$ to $x = B$.

$$S = z c'_{a\infty} \frac{\varrho}{2} U^2 R t_o \int_A^B x^2 (1 + px) \left(\vartheta_0 + \vartheta_1 x + \frac{\vartheta_2}{x} + \frac{\delta}{x}\right) dx\,; dr = R dx$$

With introduction of the abbreviations

(13) $$D_n = \int_A^B x^{n-1} (1 + px)\, dx = \frac{x^n}{n} + p \frac{x^{n+1}}{n+1}\Bigg|_A^B \qquad n = 1\,; 2 \ldots$$

the thrust thus becomes

(14) $$S = z c'_{a\infty} \frac{\varrho}{2} U^2 R t_o [\vartheta_0 D_3 + \vartheta_1 D_4 + \vartheta_2 D_2 + \delta D_2] \qquad [kg]$$

For the thrust coefficient k_n, defined as follows,

(15) $$S = k_n \cdot \frac{\varrho}{2} U^2 F \qquad F = \frac{D^2 n}{4}$$

one finally obtains

(16) $$k_n = c'_{a\infty} \sigma_o [\delta D_2 + \vartheta_0 D_3 + \vartheta_1 D_4 + \vartheta_2 D_2]$$
$$\sigma_o = \frac{z t_o}{R\pi}\,; \; \sigma_{0.7} = \frac{Z t_{0.7}}{R\pi} = \textit{Surface density}$$

The lower integration limit A is of the order of $A = 0.1$. In view of the losses induced at the extremities, B should not be taken as equal to 1, but a little less, about 0.98. The following approximation formula, the derivation of which cannot be included here, may be used :

(17) $$B = 1 - \frac{0.7}{z} \sqrt{k_n}$$

In an analogous manner, the torque moment is obtained. The following applies to an element :

$$dM = c_t \frac{\varrho}{2} v_{res}^2 t\, r\, dr$$

The total torque moment is obtained by again integrating along the blade :

$$M = z \frac{\varrho}{2} U^2 R^2 t_o \int_A^B x^3 (1 + px)\, c_t\, dx$$

The torque moment coefficient k_d, which is also the power coefficient and is determined as follows,

(18) $$\textit{Torque moment :}\ M = k_d \frac{\varrho}{2} U^2 F R \quad [mkg]$$

(19) $$\textit{Power :} \qquad N = \frac{k_d}{75} \frac{\varrho}{2} U^3 F \quad [H.P.]$$

thus amounts to

(20) $$k_d = \sigma_o \; [(c_{w_2} - c'_{a\infty})\, \delta^2 D_2 + \delta (2 c_{w_2} - c'_{a\infty}) (\vartheta_0 D_3 + \vartheta_1 D_4 + \vartheta_2 D_2)$$
$$+ c_{w_2} (\vartheta_0^2 D_4 + \vartheta_1^2 D_6 + \vartheta_2^2 D_2 + 2\vartheta_0\vartheta_1 D_5 + 2\vartheta_0\vartheta_2 D_3 + 2\vartheta_1\vartheta_2 D_4) + c_{w_0} D'_4]$$
$$D_n' = D_n \textit{ with } B = 1.$$

whereby the following estimation has been made for the airfoil drag

$$c_{wp} = c_{w_0} + c_{w_2} \alpha_{eff}^2$$

For normal airfoils, the approximate values are : $c_{w_0} = 0.011$; $c_{w_2} = 0.40$.

The flow factor $\delta = -\frac{w_a}{2U}$ still remains to be determined. Equation (2) yields $w_a/2$ and, by means of equation (15), the flow factor is made to equalise $\delta = -\frac{1}{2}\sqrt{k_n}$.

In Figs. 4 and 5, the thrust coefficient k_n and the torque moment coefficient k_d are referred to in terms of formulæ (16) and (20) for a rectangular blade, with disc densities $\sigma_{0.7} = 4$, 6, 8 and 10%, and the two linear twists $\vartheta_1 = 0°$; $\vartheta_1 = -8°$. Fig 4 and 5 also reveal the amount of deviation from the exact propeller theory, whereby the results k_n and k_d for a rectangular blade with —4° twist and 6% disc density are marked a points according to this theory. As is seen, the correspondence is extremely favourable. For precise calculation, however, particularly for assessing the influences of the Reynolds' and Mach Numbers, and to work out the exact induced losses, breakaway areas, etc., solely the propeller theory is applicable. It has been shown that the propeller theory yields results practically identical with those obtained by measurement. Wind tunnel measurements of small models are hardly transferable to large executions as the Reynolds' Numbers, and thus the airfoil characteristics, present too great differences, and considerably influence $k_{n\,max}$ and k_d.

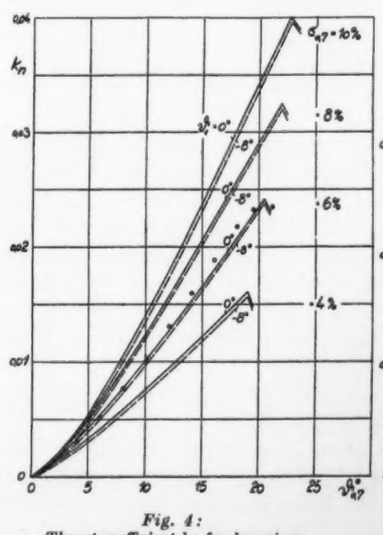


Fig. 4:
Thrust coefficient k_d for hovering.
• Propeller theory: $\sigma_{0.7} = 6\%$; $\vartheta_1 = -4°$

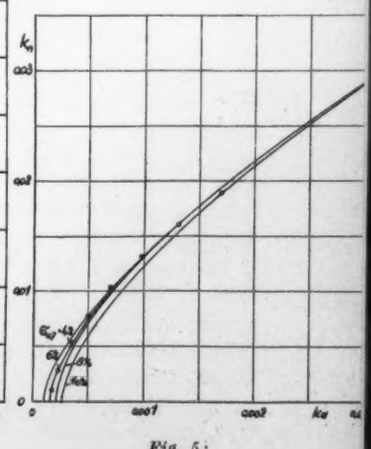


Fig. 5:
Power coefficient k_n for hovering.
• Propeller theory: $\sigma_{0.7} = 6\%$; $\vartheta_1 = -4°$

With the aid of these coefficients (k_n and k_d) the performance calculations can be executed very simply with formulæ (15) and (19). The method is principally contingent upon the initial data. In order to obtain an overall view of the values corresponding to optimum conditions, the following transformations must be done : starting with equations (15) and (19), the blade tip speed U is eliminated. The result is the same equation, but with the performance factor ζ_L :

$$\zeta_L = \frac{k_n^{3/2}}{2\,k_d} \tag{21}$$

For rectangular blades of 4 to 10% disc density, with k_n and k_d as in Figs. 4 and 5, the ζ_L performance factors are plotted in Fig. 6 in terms of formula (21). Discernible is that, initially, the performance factor augments rapidly as the blade angle of incidence $\vartheta_{0.7}$, or k_n value, increases, and only slowly from $\vartheta_{0.7} = 12^\circ$ onward. In order to obtain an accurate idea of the effective angles of incidence, of c_a values, with which the blades are working (i.e., to what extent the blades are loaded aerodynamically), the mean value of c_a can be calculated by means of the δ = constant theory :

$$\overline{c_a} = 3.2\frac{k_n}{\sigma_{0.7}} \tag{22}$$

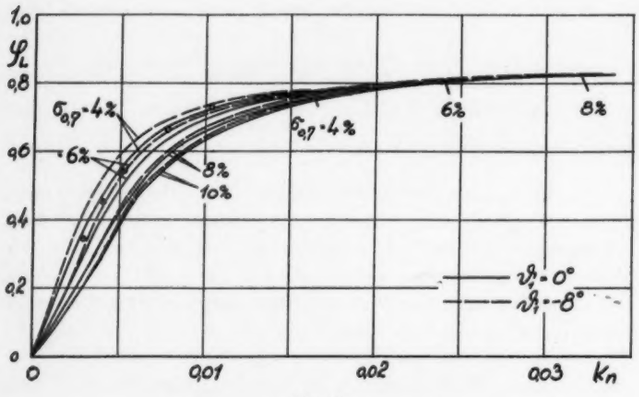


Fig. 6 :
Performance factor ζ_L for hovering flight.
• Propeller theory : $\sigma_{0.7} = 6\,\%$; $\vartheta_1 = -4^\circ$.

In order to lift as great a weight as possible with a predetermined power, first choice will fall on a low rotor disc loading S/F, which lies between 10 and 20 kg/m² in helicopters hitherto tested (Fig. 2). Therefore, the aim will be to design a rotor incorporating the most favourable performance factor, as in Fig. 6, with low disc density and a high value of k_n, i.e., low blade tips peed. Equation (15) enables the tip speed to be worked out to

$$U = 4\sqrt{\frac{S/F}{\varrho/\varrho_0 \cdot k_n}}\;;\quad n_{R_0} = \omega \cdot 9.55\;;\quad \omega = \frac{U}{R} \tag{23}$$

Care must all the same be taken not to select the aerodynamic blade loading, thus the mean value of c_a according to equation (22), too high. Otherwise, squalls or flattening-out manœuvres, etc., would cause $c_{a\,\max}$ to be attained too rapidly, resulting in air flow break-aways which manifest themselves in various undesirable manners (perturbed rotor functioning, high torsional moments of the blades, and considerable effort required to work the stick for blade control). It has been found in test flights that 0.75 is the upper limit for the mean $\overline{c}_a$ value.

Though the above values of k_n, k_d and ζ_L are calculated for rectangular blades, they can be used with a high degree of accuracy for any forms of blade (trapezoidal, double-trapezoidal, etc.) ; this being mainly dependent on a judicious selection of disc density and blade of incidence for $x = 0.7$, hence of $\sigma_{0.7}$ and $\vartheta_{0.7}$. The performance factor of a trapezoidal blade is about 3% better than that of a rectangular one. A favourable compromise is represented by the combined rectangular-trapezoidal blade below : rectangular from $x = 0.1$ to 0.5, and thereafter trapezoidal, embodying a chord $t = t_o\,(1 - 0.7\,x)$; the entire blade, from inside to the tip, having a negative twist of 4°, thus $\vartheta_1 = -4^\circ$ (Fig. 7).

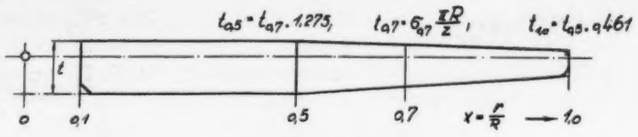


Fig. 7 :
Good helicopter blade.

Ground Effect

When a helicopter approaches the ground, its air stream can no longer escape freely, as was a predetermined condition in the above formulæ. The slipstream speed $w_a/2$ now becomes smaller, whereby the effective angle of incidence at the rotor blade, α_{eff}, increases (Fig. 3). As α_{eff} increases, the thrust naturally increases also. In Fig. 8, k_n and k_d are plotted in terms of Flachbart's measurements on the relative distance of the ground, h/D.

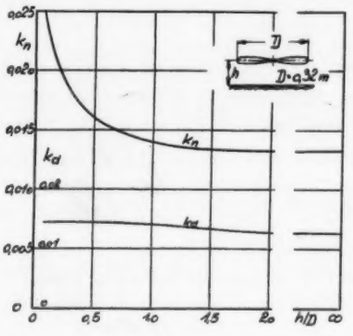


Fig. 8 :
Thrust and power coefficient with ground effect.

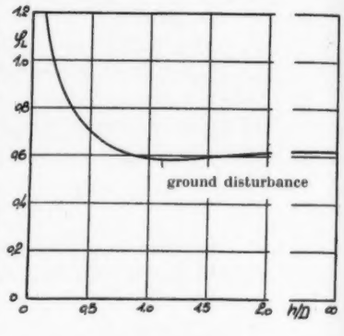


Fig. 9 :
Power performance factor with ground effect.

It is seen that whilst the thrust augments sharply as the ground is approached, the power hardly varies (the force component in the direction of rotation, c_t (Fig. 3), thus remains about the same, and the increase in c_a is compensated by the diminution of α_i). In practice, this means that the case could occur in which a helicopter is capable of unsticking at a certain throttle position, but is not able to rise more that a few metres unless the pilot opens the throttle wider. The circumstance can arise where a helicopter possessing too small a margin of power is quite incapable of escaping from this "floating position". A similar peculiarity is also to be found in the case of conventional aerodynes. The thrust augmentation on approaching the ground provides a welcome shock-absorbing effect when a landing is made consequent upon a vertical descent. From the k_n and k_d values in Fig. 8, the power performance factor, $\zeta_L = k_n^{3/2}/2k_d$, is worked out and plotted in Fig. 9. Noticeable is that a minimum results at h/D = about 1.2, which has been repeatedly ascertained in wind tunnel tests. Hence, reference may be made here to a so-called ground disturbance. It is at this altitude that a helicopter requires the greatest amount of hovering power, in reality about 7% more than at a greater distance from the ground.

Jet Drive

A method of driving a rotor by means of attaching propellers to the blade tips, has often tempted aircraft constructors ; an obvious advantage would be the suppression of torque reaction, a feature which always entails a certain complication of the construction. Due

to various reasons, however, attempted constructions of this kind have met with no success (Hellesen-Kahn, Isacco). In contrast, a method of driving a rotor with jet-propulsion is manifestly more favourable, so that a brief account of the inherent conditions is indicated.

It is assumed that jet nozzles are located towards the outer ends of the blades, in each case at a point $r = r_D$. Each nozzle delivers a thrust P_D. In the case of z blades, these jet nozzles produce a torque moment for the entire rotor of

$$M_D = z \cdot P_D \cdot r_D \qquad [mkg] \tag{24}$$

In stationary flight, this torque moment has to overcome two torque moments ; firstly, the torque moment of the air forces to which the blades are subjected, thus, according to equation (18),

$$M_L = k_d \cdot \frac{\varrho}{2} U^2 \cdot F \cdot R \qquad [mkg] \tag{25}$$

and secondly, a torque moment resulting from Coriolis forces, caused because the fuel, and eventually the air too, which is conducted from the rotor hub through the blades to the nozzles, has to be accerated in the direction of rotation to the rotative speed of the nozzles, U_D ; this torque moment amounts to

$$M_{co} = Q \cdot U_D \cdot r_D \qquad [mkg] \tag{26}$$

whereby Q denotes the mass flowing per second through the rotor blade (fuel + air, or fuel alone, according to the type of jet propulsion). Hence, in stationary flight :

$$\begin{aligned} M_D &= M_L + M_{co} \\ z\, P_D\, r_D &= k_d \frac{\varrho}{2} U^2 FR + Q U_D r_D z \end{aligned} \tag{27}$$

From equation (15), the thrust of a nozzle works out at

$$P_D = \frac{S}{z \frac{r_D}{R} k_n k_d} + Q U_D \tag{28}$$

As the most favourable location for the nozzles is obviously at the blade tips, the thrust per nozzle thus amounts to

$$P_D = \frac{S}{z\, k_n/k_d} + QU \qquad [kg] \tag{29}$$

It is not necessary to go further into the second moment caused by the Coriolis forces ; dependent on the type of jet power plant, it is far smaller than the first one in normal cases. It should be emphasised that the necessary thrust of a nozzle is totally independent of both rotor diameter and air density. The value k_n/k_d, plotted in Fig. 10, is the sole factor of fundamental importance.

It is seen here that the optimum (small nozzle thrust) is at $\vartheta_{0.7} = 7°$. Two percent of the gross weight of a helicopter with a three-blade rotor may be taken as order of the amount of thrust per nozzle.

Whereas it could be seen beforehand that $\vartheta_{0.7}$ = approx. 12° represents the most favourable condition for a conventional engine-driven helicopter, it is now apparent that jet drive entails optimum conditions requiring a smaller angle of incidence (which also applies to ordinary fixed-wing aeroplanes). If this angle of incidence is reduced to about 4 or 5 degrees, it does not involve too great a departure from optimum conditions ; it does, however, mean that a great constructional advantage arises, whereby it becomes no longer necessary to incorporate a coupling for autogyration (otherwise indispensable in case of engine cut-out). On the hand, however, care must be taken that decreasing angles of incidence, thus smaller k_n values, do not give rise to exaggerated increases in rotative speed, or tip speed (see equation 23), this in order to avoid difficulties due to too high centrifugal forces, Mach influences, etc.

Attention is drawn to the following difficulties inherent in jet-driven helicopters. It will never occur that the thrust is exactly the same at each nozzle. Consequently, the otherwise usual articulating couplings (movement of the blades in rotative direction) must be eliminated, because the differences in thrust from the separate nozzles would result in varying articulation angles, thus immediately entailing an intolerable loss of equilibrium (components of the major centrifugal forces).

In forward flight, however, the absence of articulating joints, notably in the case of large helicopters, works out to be extremely unfavourable : firstly, for reasons of mechanical resistance, as the flap oscillations, originating primarily from the Coriolis forces caused by the beating of the blades, cannot form fully, and thus place high stress on the rigid blade roots ; secondly, the forces and moments (6 components) originated by the rotor feature much greater periodical variations, so that greater difficulties as regards resistance and flight characteristics may be expected, particularly at high speeds, and which will increase all the more in the case of larger helicopters. The fuel consumption is also far greater in a jet-driven helicopter than in the conventional model, so that long durations of operation are for the present excluded. The jet drive is more suited for rapid take-off and landing conditions, whereby a normal fin and rudder unit is then adapted for torque reaction, or the apparatus flies on the ordinary autogyro principle with a conventional airscrew as medium of propulsion.

2. *Vertical Flight*

Slipstream Theory

As in the case of the hovering flight, a slipstream theory and a rotor blade theory are now to be developed for the the vertical flight condition. In front of the rotor the speed of the air is v, equal to the speed of climb. If this speed has been increased to w_a aft of the rotor, the speed in the actual rotor plane is, as can easily be demonstrated, $v + w_a/2$ (Fig. 11).

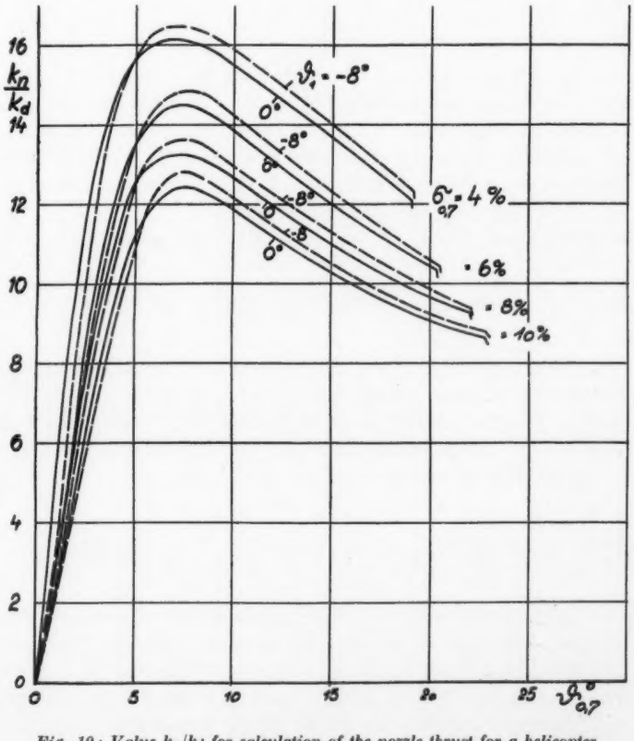


Fig. 10 : Value k_n/k_d for calculation of the nozzle thrust for a helicopter in hovering flight.

The air mass flowing per second through the rotor plane thus amounts to

$$(30) \qquad Q = \varrho F \left(v + \frac{w_a}{2}\right) \qquad \left[\frac{kg\ sec}{m}\right]$$

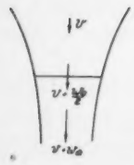


Fig. 11:
Notation to the Slipstream Theory for vertical flight.

According to the principle of momentum, the thrust is

$$(31) \qquad S = Q\,(v + w_a - v) = \varrho F \left(v + \frac{w_a}{2}\right) w_a \qquad [kg]$$

The total necessary power thus amounts to

$$(32) \qquad N'_{tot} = \frac{Q}{2}(v+w_a)^2 - \frac{Q}{2}v^2 = Q w_a \left(v + \frac{w_a}{2}\right) = S\left(v + \frac{w_a}{2}\right) \qquad \left[\frac{mkg}{sec}\right]$$

Meanwhile, the effective power is

$$(33) \qquad N'_{eff} = Sv$$

The ratio of effective power to total necessary power is, of course, the efficiency. As only the axial losses are to be accounted for in the present case, this efficiency is to be called axial efficiency, η_a, thus

$$(34) \qquad \eta_a = \frac{N'_{eff}}{N'_{tot}} = \frac{Sv}{S\left(v + \frac{w_a}{2}\right)} = \frac{1}{1 + \frac{w_a/2}{v}}$$

In terms of equation (31), w_a is

$$(35) \qquad w_a = v\left[\sqrt{1+c_n} - 1\right] \qquad c_n = \frac{S/F}{\frac{\varrho}{2}v^2} = \textit{Load factor}$$

so that the axial efficiency works out at

$$(36) \qquad \eta_a = \frac{2}{1 + \sqrt{1 + c_n}}$$

Apart from axial losses, there are other loss sources to be dealt with : firstly, the losses which occur in the tangential speed components of the slipstream, thus in the twist effect of the slipstream ; and secondly, losses caused by blade resistance to friction. These losses are expressed in two further efficiency factors, namely, tangential efficiency, η_t, and airfoil drag efficiency, η_{cwP}. Hence, the total efficiency $\eta = \eta_o \cdot \eta_t \cdot \eta_{cwP}$, so that the power equation is

$$(37) \qquad 75\,N\eta = Sv\,; \qquad N = \frac{S \cdot v}{75\,\eta_a \cdot \eta_t \cdot \eta_{cwP}} \qquad [H.P.]$$

The tangential efficiency η_t is so near to 1 in the case of load factors and advance factors $\lambda = v/U$ of normal helicopters, that there is sufficient warrant to set it as equal to 1. Taking η_a from equation (36), the following important relation for vertical flight may be obtained from equation (37) :

$$(38) \qquad \frac{N}{S} = \frac{1}{150\,\eta c_{w_P}} \left(v + \sqrt{v^2 + 16\,\frac{S/F}{\varrho/\varrho_0}}\right) \qquad \left[\frac{H.P.}{kg}\right]$$

For the limiting case of climbing speeds approaching zero, thus hovering flight ($v = o$), this formula must, of course, be transferred into terms of equation 7. In this way it is evident that as $v = 0$ is approached, or rather for $\lambda = v/U = 0$, the airfoil drag efficiency η_{cwP} becomes equal to the static thrust performance factor ζ_L (equation 21, Fig. 6). As the advance factors invariably remain very small in vertical ascent conditions, there is sufficient justification to set $\eta_{cwP} = \zeta_L$. Moreover, this can be proved to be an extremely accurate approximation by more precise calculation.

The relation between power, rotor thrust and rate of climb (equation 38) is plotted in Fig. 2 in terms of climbing speeds $v = w = 0$ to 10 m/sec. By this means, the climbing power and climbing speed of a helicopter in vertical flight can immediately be obtained. The fact that a number of types are plotted on the graph provides a good overall view of the power of various helicopters. The corresponding fundamental values of η_G and η_E are to be found further above. In precise calculations, their values have to be worked out separately, but it will be found generally that they do not vary substantially from those used here.

Rotor Blade Theory

Exactly as in the case of the hovering flight, distinction will also be made now between a simple theory with constant flow δ, and an exact propeller theory. Again, as in the case of the hovering flight, the thrust and the power N can be expressed by the coefficients k_n and k_d, thus

$$(39) \qquad S = k_n \frac{\varrho}{2} U^2 F \qquad [kg]$$

$$(40) \qquad N = \frac{k_d}{75}\frac{\varrho}{2} U^3 F \qquad [H.P.]$$

The δ = constant theory is entirely identical to that pertaining to hovering flight. The same expressions result for k_n and k_d (equations 16 and 20). Solely in the case of the flow factor does a new expression arise, namely (with equation 35)

$$\delta = -\frac{v + \frac{w_a}{2}}{U} = -\frac{v}{U}\left(1 + \frac{1}{2}\sqrt{1+c_n} - \frac{1}{2}\right)$$

or with $\lambda = v/U$

$$(41) \qquad \delta = -\frac{\lambda}{2} - \frac{1}{2}\sqrt{\lambda^2 + k_n}$$

$c_n = k_n/\lambda^2$ from $S = k_n \frac{\varrho}{2} U^2 F = c_n \frac{\varrho}{2} v^2 F$

For hovering flight, thus $\lambda = 0$, this expression reverts to the relation of $\delta = -\frac{1}{2}\sqrt{k_n}$, mentioned above. The thus calculated values for the thrust coefficient k_n and the power coefficient k_d are plotted in Figs. 12 and 13, and this, namely, for a rectangular blade of 6% surface density, with the advance factor λ and the angle of incidence $\vartheta_{0.7}$ as parameters. It has been ascertained that, as in stationary flight, the results obtained by this simple theory (in the case of well-conceived rotors incorporating the condition of uniform flow) practically coincide with those derived from the exact propeller

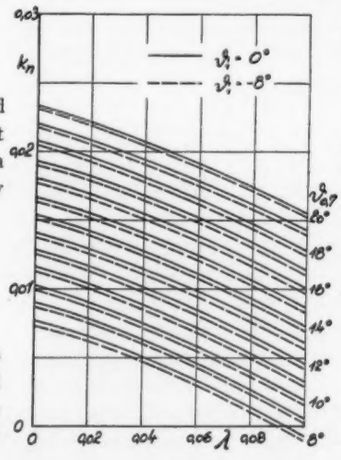


Fig. 12:
Thrust coefficient k_n for vertical ascent.

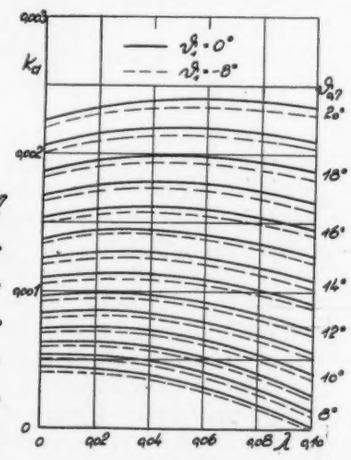


Fig. 13:
Power coefficient k_d for vertical descent.

theory. For special examinations, however, such as influences of Reynold's and Mach Numbers, break-away areas, exact induced losses, etc., there remains but to apply the propeller theory.

With the help of these coefficients, k_n and k_d, the vertical climbing flight can easily be calculated, and this for rotors with rigidly attached blades as well as such incorporating controllable pitch ; the latter involves an automatic adjustment of the blade angle of incidence $\vartheta_{0,7}$ in order to evolve a determined rotative speed. In the case of *fixed-pitch rotors*, the calculation procedure is roughly as follows : one calculates the power N and the climbing speed $v = \lambda U$ by means of U, k_n, λ and k_d for different rotor rotative speeds n_{Ro}. Where *variable pitch rotors* are concerned, n_{Ro}, U and k_n being given, the power N and rate of climb $v = \lambda U$ are worked out for a series of λ values.

It may be mentioned that in stalling flight with engine declutched (in autogyration) a c_n value of about 1.2 can be estimated, which simultaneously corresponds to a complete density of rotor disc. With this, the speed of descent in stalling flight works out at

$$w_s = 4 \sqrt{\frac{G/F}{\varrho/\varrho_0 \cdot 1.2}} \quad \left[\frac{m}{sec}\right] \tag{42}$$

which, however, is intolerably high for landings under normal disc loading conditions. Hence, in a case of engine cut-out, a glide descent in autogyration is recommendable.

3. *Horizontal Flight*

In order to calculate the horizontal flight, i.e., maximum speed, cruising speed, range, etc., the equilibrium of forces perpendicular to, and in the, direction of flight is taken as point of departure. Hence, Fig. 3 shows the following :

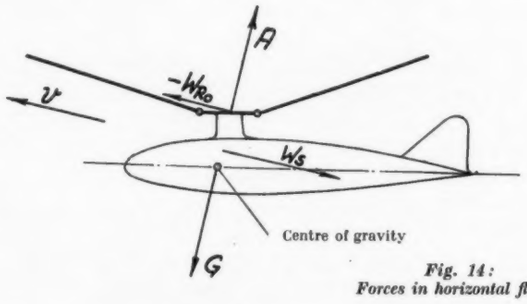


Fig. 14 :
Forces in horizontal flight.

(43) Perpendicular to course : $A - G = 0$

(44) In direction of course : $W_{Ro} + W_S = 0$

(45) Power : $N = N_{Ro}$

Whereby A = Rotor lift
W_{Ro} = Rotor drag
W_s = Parasite drag of all aircraft parts apart from the rotor.

For the individual expression the usual values are attributed.

$$A = k_a \frac{\varrho}{2} U^2 F \tag{46}$$

$$W_{Ro} = k_w \frac{\varrho}{2} U^2 F \tag{47}$$

$$W_s = f_{ws} \frac{\varrho}{2} v^2 = c_{ws} \lambda^2 \frac{\varrho}{2} U^2 F \qquad c_{ws} = \frac{f_{ws}}{F};\ \lambda = \frac{v}{U} \tag{48}$$

$$N = \frac{k_d}{75} \frac{\varrho}{2} U^3 F \tag{49}$$

Hence, it may be reckoned from equations (43), (44) and (45) that

$$G = k_a \frac{\varrho}{2} U^2 F \tag{50}$$

$$k_w = - c_{ws} \lambda^2 \tag{51}$$

$$N = \frac{k_d}{75} \frac{\varrho}{2} U^3 F \tag{52}$$

By eliminating U from equations (50) and (52), there results

$$N = \frac{G}{k_a^{3/2}/2k_d} \sqrt{\frac{G/F}{\varrho/\varrho_0\, 1410}} \qquad [H.P.] \tag{53}$$

As in the case of the hovering flight, the expression $k_a^{3/2}/2k_d$ is characterised with the performance factor ζ_{LV}. so that

$$\zeta_{LV} = \frac{k_a^{3/2}}{2k_d} \tag{54}$$

For the case of horizontal speeds diminishing towards zero, thus $v = 0$, the expression ζ_{LV} must also revert to the hovering performance factor ζ_L (equation 21)

In order to obtain a reference for the horizontal speed v, the two equations (50) and (52) may again be used. By multiplying equation (50) by v and dividing the result by equation (52), one obtains

$$v = 75 \frac{N}{G} \eta_s \qquad \left[\frac{m}{sec}\right] \tag{55}$$

$$\eta_s = \frac{k_a}{k_d} \lambda \tag{56}$$

whereby η_s signifies the high speed efficiency. As is discernible from equations (54) and (56), the relation between ζ_{LV} and η_s is

$$\zeta_{LV} = \eta_s \frac{\sqrt{k_a}}{2\lambda} \tag{57}$$

To be concluded next month.

Laminar Flow Airfoils with Boundary Layer Suction

By W. PFENNINGER, D.Sc.

Preface:

The trend in modern aircraft design is to reduce to a minimum frictional resistance which generally represents the main drag factor. This can be achieved by continued maintenance of laminar flow in the boundary layer on the wing, fuselage and tail plane of the aircraft, as laminar surface friction is substantially lower than turbulent friction. In the past few years these considerations have led to the development in different countries of so-called " laminar-flow airfoils " of low airfoil drag. On these airfoils the breakdown of laminar flow (transition from laminar to turbulent boundary layer) occurs further to the rear of the airfoil as this is designed to assume its maximum thickness at a point further back than has hitherto been customary [1], [2], [3], [4].

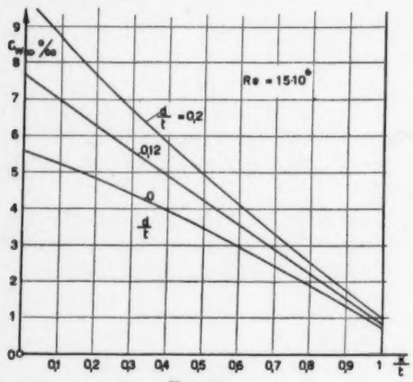


Fig. 1:
Influence of position of transition point on airfoil drag, for varying airfoil thicknesses, at $Re = 15 \times 10^6$.

Fig. 1 shows how the airfoil drag $c_{w\infty}$ (computed according to Squire-Young, [11]) would decrease with an increasing ratio x/t (distance of the transition point from the leading edge in relation to wing chord) for airfoils of different thickness d/t and a Reynolds number $Re = \frac{U_0 t}{\nu} = 15 \times 10^6$ applying to an average aircraft. In the optimum case of the boundary layer maintained fully laminar right to the trailing edge of the wing, very low values of airfoil drag at higher Reynolds numbers would be possible even with thicker airfoils, desirable from both strength and design reasons. It has been found that suction is an efficient means to keep the boundary layer over a airfoil completely laminar [4].

Principle of laminar boundary layer suction and resultant laminar pressure increase.

In the leading section of the wing with its accelerated flow the boundary layer normally remains laminar, at least so long as no surface disturbances (roughness of skin, slight wave) or exterior turbulence cause a premature transition. However, in the region of rising pressure on the rear portion of the airfoil, the innermost elements of the boundary layer are decelerated to such an extent that near the wall a slight blackflow occurs (beginning of laminar separation). It has been found that a laminar boundary layer is then highly unstable and quickly becomes turbulent. Now, if with rising pressure these critical elements of the boundary layer in the immediate vicinity of the wall are removed by suction before laminar separation takes place, then much higher pressure rises should be possible in a laminar boundary layer.

Thus, experiments in a suction tunnel with three consecutive suction slots yielded a pressure rise in the laminar boundary layer of 63% of the pressure difference between the stagnation point and the point of minimum pressure, as compared with corresponding values of 11–12% without suction [4].

The suction slots (shaped as shown in Fig. 3) were fitted in a flat measuring plate. The exterior pressure distribution could be altered by adjusting the opposite wall of the tunnel. The so-called sink effect(*) contributes essentially to the pressure rise under laminar conditions.

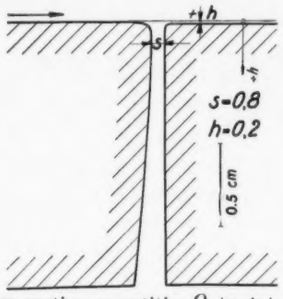


Fig. 3: Shape of suction slot.

With larger suction quantities Q_a/Q_δ* (see notations) the pressure rise due to sink effect can be amplified by providing a step in the surface at the suction point (Fig. 4). By this measure considerable pressure rises could be achieved with a single suction slot before transition took place (Figs. 5 and 6). With smaller suction quantities Q_a/Q_δ*, such a step in the surface could be dispensed with.

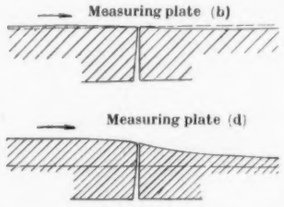
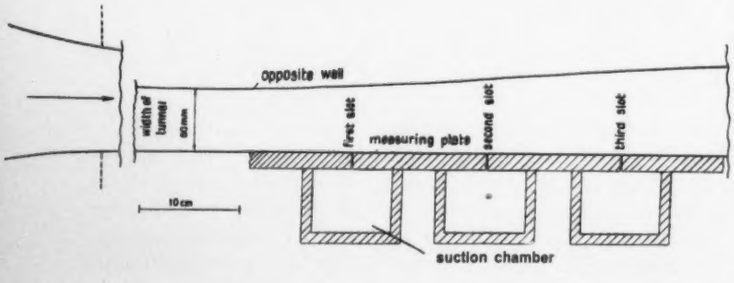


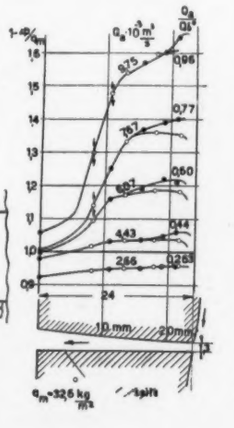
Fig. 4: Measuring plate (b) and (d) with the suction slot (b). This was set at a point corresponding to the position of the first slot in the experiment with 3 slots.

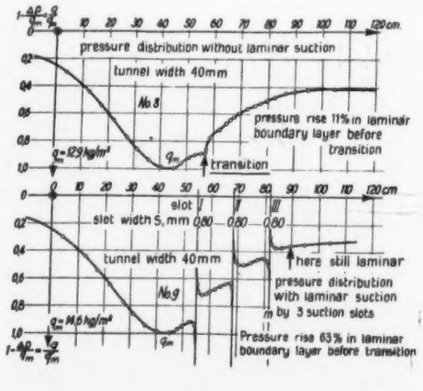
The first experiments on a slightly cambered laminar suction airfoil of 6.75% thick-

* The sink action of the suction point produces in its vicinity an accelerated pressure field which, superimposed over the exterior flow, brings about an unsteady and sudden rise of pressure at the suction point and a diminution of the pressure rise along the wall between the suction slots.

Fig.: 2
Laminar boundary layer suction experiments with three suction slots in line. Set-up, static pressure at measuring plate with and without suction.






pressure distribution without laminar suction
tunnel width 40mm
No 8
pressure rise 11% in laminar boundary layer before transition
transition
slot
slot width s, mm 0,80 0,80 0,80
tunnel width 40mm
here still laminar
No 9
pressure distribution with laminar suction by 3 suction slots
Pressure rise 63% in laminar boundary layer before transition

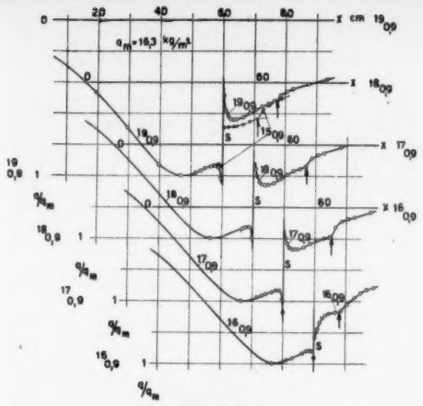


Fig. 5:
Laminar boundary layer suction tests with slot (b) and measuring plate (b). Influence of suction quantity Qa on the rise of pressure in laminar boundary layer up to transition (arrow) and on the sink effect. b = 0.4 m.

No.	190.9	180.9	170.9	160.9	150.9
$Qa \cdot 10^{-3}$ m^3/sec	5.67	4.07	2.76	1.19	1.59
$Qa/Q\delta^*$	0.674	0.483	0.328	0.141	0.189

δ^* = displacement thickness ahead of slot.

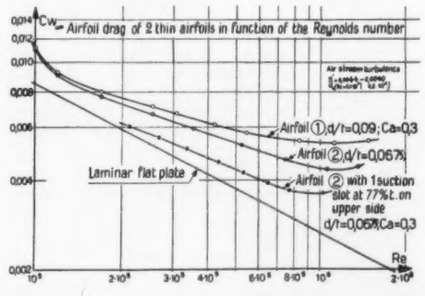
ness, with a single suction slot in the upper surface at a distance of 0.77 t from the leading edge, confirmed that suction enabled the boundary layer over an airfoil to be kept completely laminar, and that low values of airfoil drag can be obtained with very small suction quantities (Fig. 7, [4]).

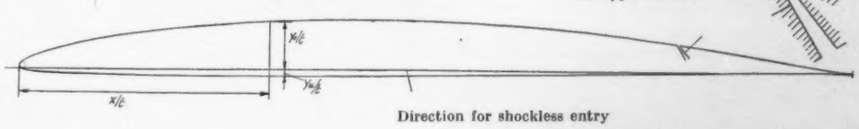
In Fig. 7 the optimum airfoil drag $c_{w_{\infty}\,min}$ without and with suction (power required for suction blower included) has been plotted against the Reynolds number $Re = \frac{U_0 t}{\nu}$ (**).

Up to Reynolds numbers $Re = 0.8 \times 10^6$ the boundary layer with suction remained completely laminar, with $c_{w_{\infty}}$ only slightly higher than the laminar friction drag of a flat plate. The rise of pressure in the laminar boundary layer along the upper surface of the airfoil from the point of minimum

** The computation of drag from the results obtained in the suction experiments was based on the assumption that the suction air was accelerated to the velocity U_o of the undisturbed flow and that airscrew and suction blower had equal efficiency [4]. By accelerating the suction air to U_o, part of the kinetic wake energy is recovered and the drag thereby further reduced. The possibility of reducing wing drag by recovery of the kinetic wake energy has already been pointed out by Prof. Dr. J. Ackeret [5].

Fig. 7:
Laminar flow suction airfoil 2 with a single suction slot on upper surface. Maximum airfoil thickness d/t = 0.0675 at 0.394 t from leading edge. Minimum width of slot s = 0.9 mm. $c_{w_{\infty}\,opt}$ without and with laminar boundary suction.


Airfoil drag of 2 thin airfoils in function of the Reynolds number
Airfoil ①d/t=0,09; Ca=0,3
Airfoil ②d/t=0,067
Laminar flat plate
Airfoil ② with 1 suction slot at 77%t. on upper side d/t=0,057 Ca=0,3
Re



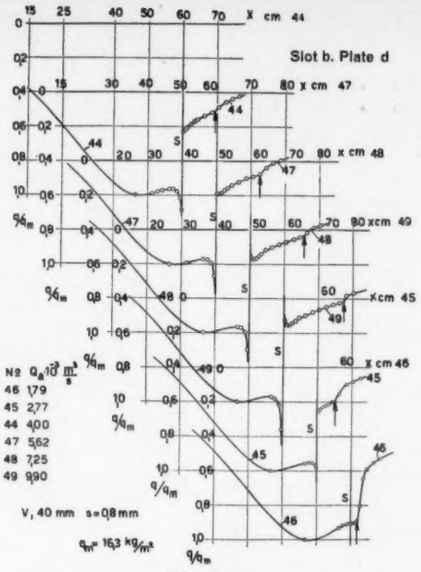


Fig. 6:
Laminar boundary layer suction tests with slot (b) and measuring plate (d); b = 0.4 m. Influence of suction quantity Qa on the rise of pressure in laminar boundary layer up to transition (arrow) and on the sink effect.

pressure to the trailing edge was 35%. At higher Reynolds numbers transition occurred already ahead of the suction slot under the influence of tunnel turbulence. Despite suction, the boundary layer in this case also remained turbulent behind the suction slot, and the drag rose again accordingly.

Notations:

t	=	wing chord
b	=	span of wing over area of suction measurement
$F = b \cdot t$	=	wing area subjected to suction
s	=	minimum width of slot
d/t	=	airfoil thickness
f/t	=	camber of airfoil centre line
R_o/t	=	leading edge radius
q_o	=	dynamic pressure of undisturbed flow
U_o	=	velocity of undisturbed flow
p	=	static pressure at airfoil surface
p_a	=	static pressure in suction chamber
Δp_g	=	pressure of suction blower, $\Delta p_g = q_o - p_a - \frac{\varrho}{2} u_L^2$, when the suction air is accelerated to U_o, and for equal efficiency of airscrew and suction blower
$\varrho/_2 \cdot u_L^2$	=	kinetic energy of suction air in suction chamber, perpendicular to the wing
q	=	local dynamic pressure at edge of boundary layer
q_m	=	maximum dynamic pressure at edge of boundary layer, at the point of minimum pressure
Q_a	=	suction quantity

Boundary layer:

Displacement thickness $\delta^* = \int_0^{\delta} \left(1 - \frac{u}{U}\right) dy$

where u = velocity in boundary layer at the distance y from the wall

U = velocity at edge of boundary layer at the distance δ from the wall

Momentum thickness: $\theta = \int_0^{\delta} \frac{u}{U}\left(1 - \frac{u}{U}\right) dy$

Reynolds numbers:

$$Re = \frac{U_0 t}{\nu}, \quad Re = \frac{U \cdot \theta}{\nu}, \quad Re_{\delta_*} = \frac{U \cdot \delta^*}{\nu}$$

Drags and non-dimensional coefficients:

Drag portion due to wake W'_{∞}, with coefficient $c'_{w_{\infty}} = \frac{W'_{\infty}}{q_o \cdot F}$, determined by wake measurements [6]

Drag portion due to suction blower W_g with coefficient $c_{w_g} = \frac{W_g}{q_o \cdot F}$ and

$c_{w_g} = \frac{Q_a \cdot \Delta p_g}{U_o \cdot F \cdot q_o} = c_Q \cdot c_{p_g}$, where

$c_Q = \frac{Q_a}{U_o \cdot F}$ = suction quantity coefficient, and

$c_{p_g} = \frac{\Delta p_g}{q_o}$ = suction blower pressure coefficient

total airfoil drag for the determination of the propulsion power required, W_{∞}, with coefficient $c_{w_{\infty}}$

$c_{w_{\infty}} = \frac{W_{\infty}}{q_o \cdot F} = c'_{w_{\infty}} + c_{w_g}$ (acceleration to U_o of the suction air)

c_a = lift coefficient

wind tunnel turbulence $\frac{u'}{U_o} = 0.004$ to 0.0045

The flow near the suction point has been made visible by flow tests in the water tank, using Al-dust [4]; see Figs. 8, 9 and 10. Laminar suction works correctly even with widely varying slot shapes and suction quantities. With suction slots inclined forward, and also when the rear edge of the slot is set well down, the intensity of suction should not be too low as, otherwise, the boundary layer is likely to suffer laminar separation at the slot inlet.

For the practical application of boundary layer suction small pressure losses in the suction slots play a decisive rôle. This was achieved by designing the suction slots as diffusers ([4]; see Figs. 3 and 7; see also the experiments on turbulent suction by A. Gerber [7]). In the slot diffuser part of the kinetic energy contained in the suction air is transformed into pressure. Subsequently, a more or less substantial rise of pressure occurs in the slot, and the static pressure in the suction chamber increases so as to exceed the pressure at the slot inlet.

The slot losses become particularly low when the flow in the slot diffuser becomes turbulent and when there is uniform velocity

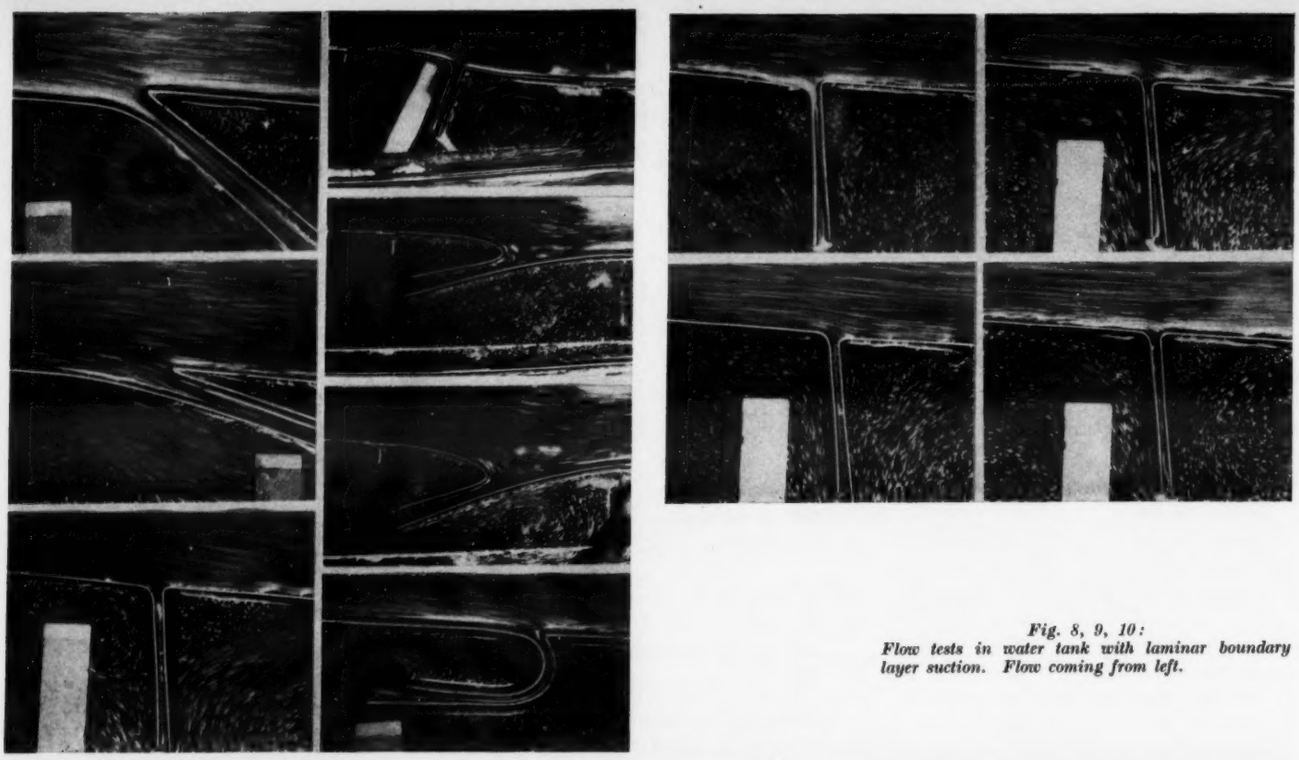


Fig. 8, 9, 10:
Flow tests in water tank with laminar boundary layer suction. Flow coming from left.

distribution in the suction air at the slot outlet (Fig. 11), provided the Reynolds number of the slot flow is sufficiently high. At the presumable point of transition the static pressure in the slot rises rapidly, similar to the normal transition of boundary layer along a wall or airfoil, as shown in Fig. 17, for instance.

At low values of Reynolds number of the slot flow, laminar separation of the flow occurs along one wall of the slot. The rise of pressure in the slot diffuser is then considerably lower and the slot losses increase. It is possible artificially to render turbulent the flow in the slot at much lower Reynolds numbers, for instance, by giving the slot a concave curvature (3) as shown in Fig. 12. The rise of pressure in the slot is thereby increased. See Fig. 13 for static pressure distribution ahead of the slot and in the slot diffuser.

Maintaining laminar boundary layer at high values of Reynolds number by means of boundary layer suction [4]

Transition experiments have shown that the breakdown of laminar flow as a result

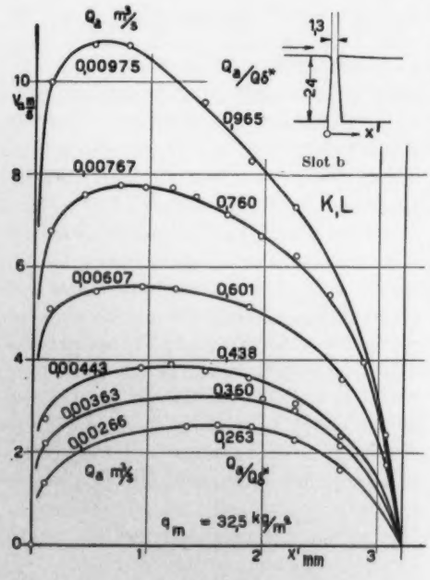
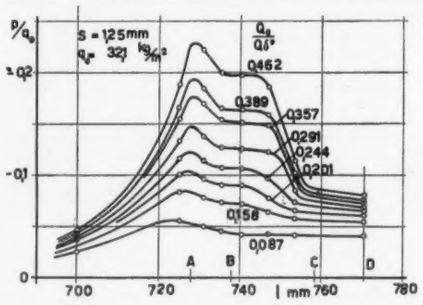


Fig. 11:
Velocity distribution at slot outlet and static pressure along inside of slot diffuser for different suction quantities.

(3) For the unstabilizing effect of a concave curvature on laminar boundary layer see [8], [9].

Fig. 13:
Static pressure p/q_0 ahead of slot (h) and in slot diffuser for different suction quantities Q_a/Q_δ^*. Slot (h) was on the lower wing surface at 0.73 m from leading edge.



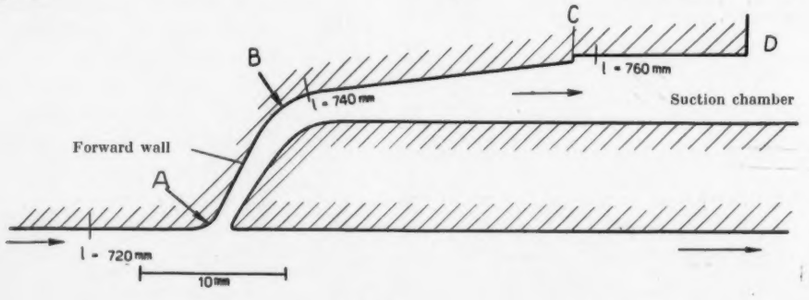


Fig. 12:
Suction slot (h) curved backward.

of exterior turbulence sets up as soon as a critical value of boundary layer thickness or a critical value of Reynolds number related thereto (for instance, $Re_{\theta\,crit} = \left(\frac{U \cdot \theta}{\nu}\right)_{crit}$) is exceeded. Accordingly, a critical value of Reynolds number, $Re_{x\,crit}$, related to the distance x of the point of transition from the front stagnation point, is reached. The suction method now provides an artificial means of preventing the thickness of boundary layer from increasing. This should enable higher Reynolds numbers, in relation to the distance of the transition point from the front stagnation point, to be reached under laminar conditions. This supposition was confirmed by laminar suction tests on a symmetrical airfoil of 3.35% thickness. $Re\theta_{crit}$ was of practically the same magnitude with and without suction, with the same uniform pressure distribution. The airfoil tested with its eight suction slots appears in Fig. 14. The slots were inclined 55° backwards, and again designed as diffusers (Fig. 15).

To increase the sink effect the surface was slightly recessed in the vicinity of the suction slots. The suction tests were carried out along the measuring surface, while measurements on the opposite surface made it possible to effect a comparison with non-suction conditions. The minimum values of drag with and without suction, computed for both surfaces of the airfoil, are shown plotted against $Re = \frac{U_o t}{\nu}$ in Fig. 16.

With suction, and up to $Re = 4 \times 10^6$, $c_{w\infty}$ only slightly exceeded the laminar friction drag of the flat plate: $c_{w\infty\,min} = 0.00167$ at $Re = 4 \times 10^6$, power required for suction blower included. The rise of drag owing to tunnel turbulence only set in at much higher Reynolds numbers as compared to non-suction conditions.

Some curves of pressure distribution over the chord of the airfoil with characteristic unsteadiness at the suction points are shown in Fig. 17. Transition occurred mostly near the trailing edge (arrow).

Further suction experiments on an airfoil of 10.5% thickness [4], with conventional thickness distribution, likewise showed a considerable diminution of drag as a result of suction. The shape of the airfoil, with slots, is apparent from Fig. 18. $c_{w\infty\,min}$ with suction (including power required for suction blower) for different values of c_a, as well as $c_{w\infty\,min}$ without suction, are shown plotted against Re in Fig. 19.

By means of suction the airfoil drag is reduced by a little over one half: $c_{w\infty} = 0.0023$ at $Re = 2.2 \times 10^6$. The increase of drag at higher Reynolds numbers is again due to the effect of tunnel turbulence ($u'/U_o = 0.004$ to 0.0045).

The airfoil drag polars c_a ($c_{w\infty}$) with suction (Fig. 20) show a comparatively wide

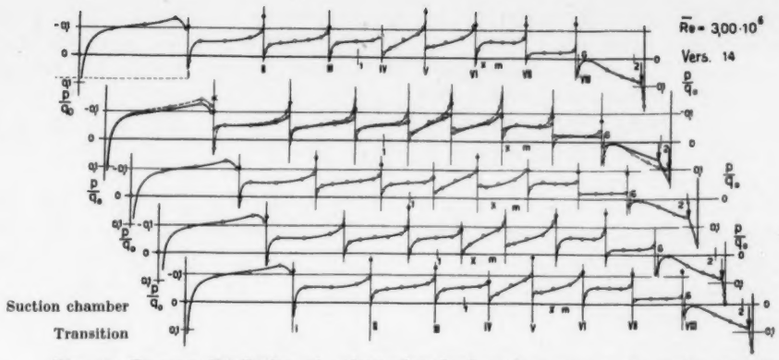


Fig. 17: Pressure distribution p/q_0 along wing chord, static pressure in the suction chambers (solid circles) and beginning of transition (arrows) for different strengths of suction.

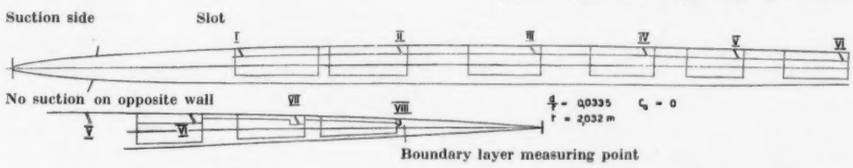


Fig. 14: Symmetrical laminar boundary layer suction airfoil, $d/t = 0.0335$, $t = 2.032$ m.

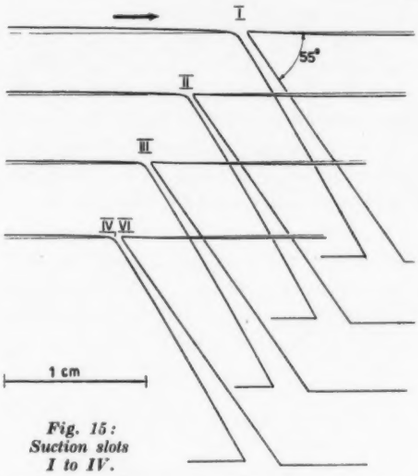


Fig. 15: Suction slots I to IV.

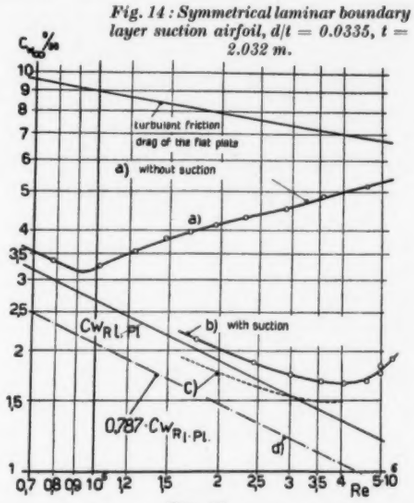


Fig. 16: Curve of drag $c_{w\infty}$ without (curve a) and with (curve b) laminar boundary layer suction. The rise of drag at higher Re occurs as a result of wind tunnel turbulence.
l = laminar friction drag of the flat plate (Blasius)
t = turbulent friction drag of flat plate (Schlichting).

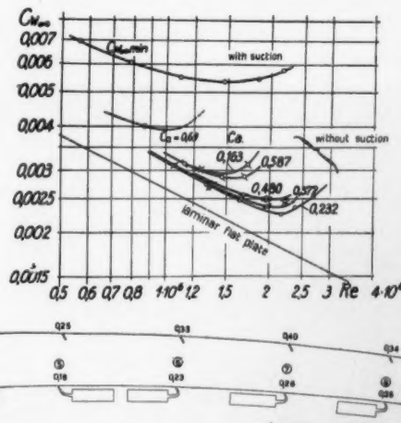


Fig. 19: →
Laminar boundary layer suction airfoil, $d/t = 0.105$. Drag $c_{w\infty}$ with suction (including power required for suction blower) for different values of Re and c_a, and $c_{w\infty\,min}$ without suction.

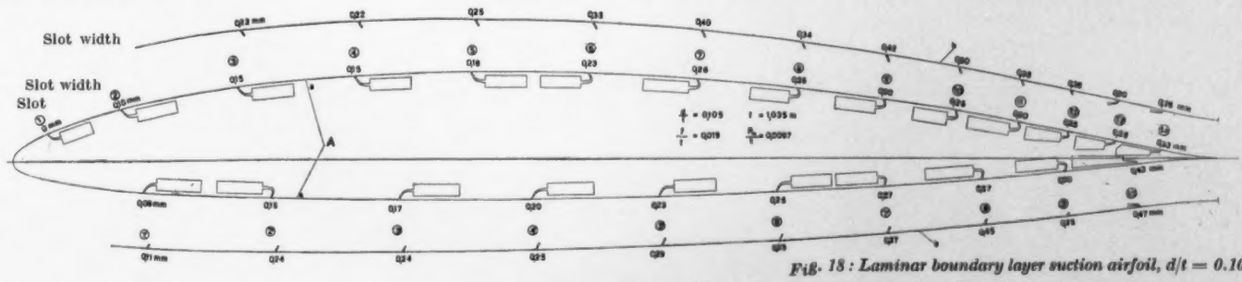


Fig. 18: Laminar boundary layer suction airfoil, $d/t = 0.105$

lift range with low airfoil drag and low values of lift/drag ratio. Within this c_a range the boundary layer could be maintained completely laminar with the aid of suction. At higher or very low values of c_a the boundary layer along the upper or lower surface of the wing ultimately becomes turbulent in spite of suction, this owing to the appearance of negative pressure peak at the wing leading edge, and drag increases very sharply.

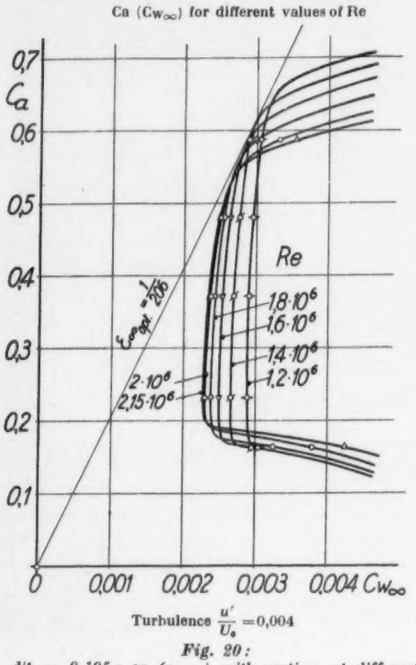


Fig. 20:
d/t = 0.105; ca ($c_{w\infty}$) with suction, at different value of Re.

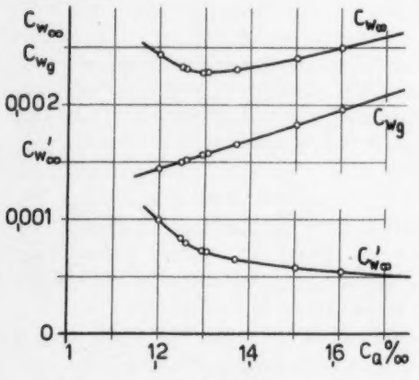


Fig. 21
d/t = 0.015, Re = 2.2×10^6. Influence of suction quantity (coefficient c_Q) on $c'_{w\infty}$, c_{wg} and $c_{w\infty}$.

The influence of the suction quantity c_q on $c_{w'\infty}$, c_{wg} and $c_{w\infty}$ is shown in Fig. 21. The lowest value of airfoil drag was obtained when, with a minimum of suction ($c_{q_{opt}}$), the boundary layer could just be maintained laminar on both surfaces up to the trailing edge of the wing. With even lower suction, burbles were observed in the boundary layer, which again increased the drag. The drag due to the suction blowers and the wake amounted for $c_{q_{opt}}$ to approximately 2/3 and 1/3, respectively, of the total drag. The pressure distribution over the chord (Fig. 22) shows again the uneven rise of pressure caused by the sink effect of the points of suction. At higher values of c_a considerable pressure rises in the laminar

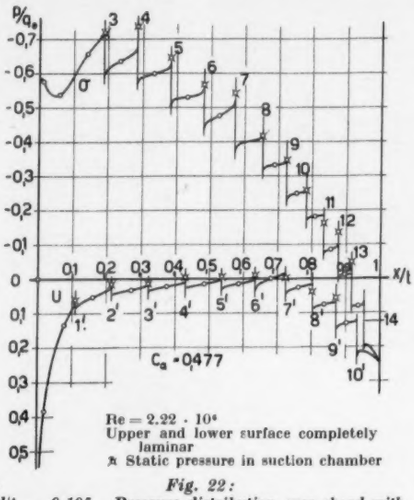


Fig. 22:
d/t = 0.105. Pressure distribution over chord with suction.

boundary layer on the upper surface were obtained. Recent experiments yielded such pressure rises of up to 85% of the pressure difference between the forward stagnation point and the point of minimum pressure.

All previous suction experiments have shown that, no matter whether suction is applied or not, a laminar boundary layer is considerably more stable with accelerated flow than with a rise of pressure. It should, therefore, prove favourable as regards drag to select laminar flow airfoils with sections yielding a uniform distribution of pressure, rising at a point fairly near the trailing edge. This supposition was confirmed by further experiments on a laminar flow suction airfoil of 17% thickness at 0.45 t from the leading edge, inasmuch as the same minimum drag was obtained as with the airfoil of 10.5% thickness (Fig. 18).

An asset for the application of laminar flow suction airfoils in flight is the fact that atmospheric turbulence is generally too low to have any appreciable effect on the breakdown of the laminar boundary layer [10]. Accordingly, the laminar boundary layer can be extended to much higher values of Reynolds number than would be possible in a wind tunnel with its inherent turbulence. During a test flight with a " Kingcobra ", for instance, the laminar boundary layer along a wing section could be maintained over about 2/3 of the wing chord, at a Reynolds number of 19×10^6. The Reynolds number Re_θ was calculated to amount to $Re_\theta \simeq 2{,}600$ at the point of transition, as compared with the critical Reynolds number of $Re_{\theta_{crit}} \simeq 900$ for laminar suction airfoils as obtained in the wind tunnel of the Federal School of Technology at Zurich, Switzerland. This would imply that by full preservation of the laminar boundary layer, in flight a further reduction of drag by about 60% should be reached at correspondingly higher Reynolds numbers. ($Re = \frac{U_0 \cdot t}{\nu} = 20\times10^6$).

So substantial a diminution of airfoil drag would give renewed importance to the problem of induced drag. This could be reduced by increasing the wing span and the speed of flight. Large spans, however, require an increase of wing thickness, which is liable to produce compressibility phenomena. In principle, fuselage, tail plane, etc., could also be maintained laminar with the aid of suction.

Laminar flow suction airfoils appear to be particularly promising in the field of large " flying-wing " aircraft. With large laminar flow suction aeroplanes the most favourable lift/drag ratio would be obtained at low values of c_a, and consequently in flight at high speeds and moderate altitudes. For cruising, a relatively small power plant (reciprocating engine or gas turbine) driving the suction blowers and possibly a pusher-airscrew would be sufficient. For take-off an additional source of thrust (gas turbine-propeller or ram-jet) is likely to be required, unless assisted take-off is resorted to (rockets, tow system suggested by Prof. Ackeret, etc.).

There is little doubt that considerable difficulties will have to be overcome in the design and construction of boundary layer suction wings. Their surface will have to be as smooth as possible, with a permissible height of undulations inferior to 1/1000 of their length. However, provided the suction ducts and slots, etc., are integrated into wing structure, the suction wing need not be much heavier than a conventional type.

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AIRPORT LIGHTING IN ENGLAND

By Squadron Leader D. West, London

Airport development being the immediate objective of all airfaring nations heightens the importance of airport lighting systems assuring safe operations at night and under bad visibility conditions.

The *Unit Control System for Airfield Lighting and Ground Traffic*, any elaborate airport lighting system officially put into operation on December 30th, 1945, at the London Airport, Heathrow, is in reality not an entirely new conception. Developed by Standard Telephones and Cables Ltd. in cooperation with the Air Ministry Works Directorate, it is a combination of the lighting systems used on Royal Air Force and U. S. Army Air Forces bases during the war, incorporating the best features of each, and may, therefore, be regarded as.

The main feature of this system is that the pilot of an incoming aircraft sees his approach path in the form of a long lane of high-intensity lights. Location of the airport is facilitated by a marker beacon flashing alternatively green and white rays which are visible from distances up to thirty miles. For optical identification of the field, a second beacon flashes a red signal in morse, which may be seen from up to twenty miles away. Flying obstructions are fitted with special red lights, duplicated for safety.

Once an aircraft is within range of the radio and radar facilities, it makes an instrument approach to a position from which the actual landing is accomplished by visual

Set up of the lighting units of an airport lighting system.

Beacon for optical identification of the airport.

reference to a lane of red lights. This is in the form of a narrow funnel, extending for a distance of about two miles. The approach lane merges into the actual runway, which is in turn defined by white contact lights. The aggregate length of a combined approach of this pattern, including approach lane and runway, may be about three miles.

At a point about one third of the distance from the end of the runway, the white contact lights may change to yellow to give pilots an indication of their position on the runway. Likewise, the commencement of the runway may be defined by a bar of green threshold lights and the end by a bar of red threshold lights.

In order to cope with the varying meteorological conditions at London Airport, lights are of two types. For fine weather conditions, low intensity ones are used, visible through 360 degrees in azimuth. For landing in poor visibility, however, higher intensity lights are provided, which are directional and have a spread corresponding to the approach lane, set to point towards the incoming aircraft. The runway lighting follows the same principle. For good weather landings, low intensity contact lights are sunk into the ground and are visible through 360 degrees in azimuth. For bad weather landings, high intensity lights are used, which are directional and point towards the oncoming pilot. The light beam is toed into the runway, with peak intensity a few degreees above the horizontal.

Past experience shows that numerous accidents and mishaps to aircraft are still to be attributed to deficient control of taxying aircraft. It is not only necessary, therefore, to light up approach lanes and runways, but also to provide sufficient and efficient illumination of taxying tracks. The system at London Airport follows the RAF war-time principle of having contrasting colours, blue on the inside and amber on the outside of the track, with the lights placed closer together on the corners and bends.

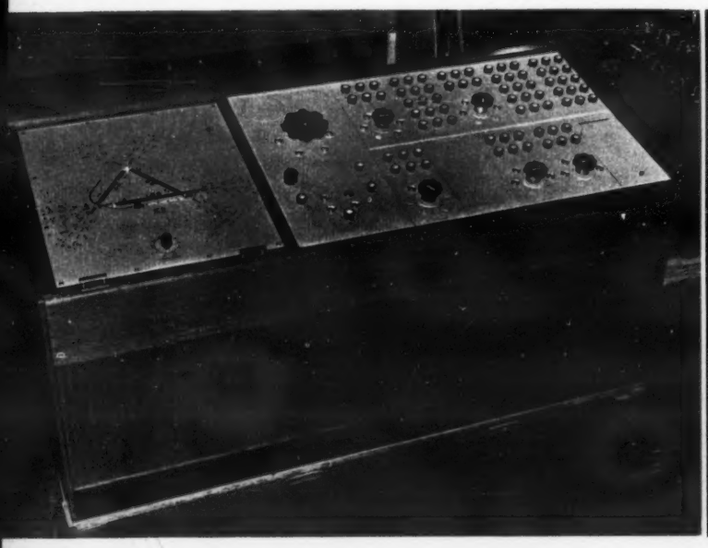
It will readily be understood that the lighting system of a large aerodrome requires corresponding servicing and control equipment. At London Airport, all services are regulated from the control desk in the control tower. The three completed runways at Heathrow are provided with over 2,100 separate electrical fittings, which are connected in a total of nearly 300 different circuits, each being operated from the central control desk. The circuits making up the approach and contact lights are known as flare path services, and are inter-locked and co-ordinated in the switch system by " runway selection ". This ensures that only those flare path services required for a given approach path can be illuminated at one time. The other services, such as taxying lights, traffic lights and the aerodrome beacon, are known as non-flare path services and can be operated individually and independently of whatever runway is selected. A Master Key enables the Aircraft Controller automatically to verify all his control operations. A fault developing on the system is immediately shown on a special lamp and, by operating the " check " facility, it can easily be located.

The control desk is built in units so that new sections to control duplicate and triplicate runways, as they become available, can be added quickly and without disturbing existing control facilities. The electrical system is conceived along the same lines. The power to operate it is drawn from an 11,000 volt ring main cable. The supply transformer substations, at present numbering twelve, are placed as close to the load centres as possible, so that new services and equipment can be connected up within the shortest lengths of new cable.

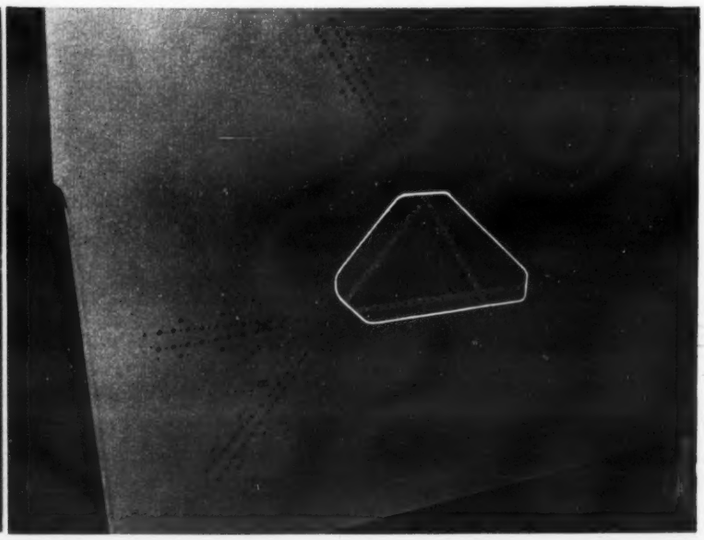
Operating speed is an important consideration and the control system is so designed that a service can be switched on in one or two seconds. Alternately, the Controller can set up for a series of lighting controls in any order he choses, putting them into operation by a single depression of the operating key. In the event of a change in the wind, he need only manipulate the one Master Runway Selection Switch and one key to change the entire system in one operation from the old to the new flare path.

The cost of the London system, a prototype unit, was about £ 18,000, but it is anticipated that on a quantity production basis, this price will be considerably lower, possibly £ 12,000.

Central control desk in the airport control tower, with lighting plan, master key, operating keys and runway selection switch.



Lighting plan at London Airport, Heathrow.



In annex to Squadron Leader D. West's article on airport lighting in England, brief allusion may be made to a number of fundamental questions on airport lighting, and the contributions the item of airport equipment makes towards safety in all-weather flying. At the same time, mention is made of a lighting system developed in the United States by *Line Material Co.*, of East Stroudsburg, Pa., which is so far the only scheme to work with High Intensity Lights of varying strength. Known as the *Bartow System*, it was invented towards the beginning of the war by Jack Bartow, an electrical engineer and experienced night-flyer. Initially confined to U. S. and Allied air bases, it was not until 1946 that the system was released to civil aviation. Meanwhile, in view of its exceptional advantages and following the satisfactory results obtained in trials in all bad-weather regions of the world, its general adoption has been recommended by the U.S. Civil Aeronautics Administration and by the Air Transport Association of America. During the war the Bartow System was installed at over a hundred Allied air bases, and today, in addition to Idlewild, LaGuardia Field, Chicago, Kansas City, Boston and Baltimore, there are over a dozen other airports in the U. S. A. using it. It was also chosen for the National Airport, Panama ; National Airport, Buenos Aires ; and several airfields in Venezuela. As our photos show, Bartow lamps are also incorporated in the London system. It is soon to come into operation at Shannon Airport, Rineanna, Ireland ; and Orly Airport, Paris, is still in possession of the Bartow equipment left behind by the U. S. Army. Negotiations are at present under way for similar installations at Schiphol, Amsterdam, and at the new Melsbroek Municipal Airport, Brussels.

The Editor.

The crashes of the past few months have brought it home to the public and to the authorities of the airfaring nations that every effort must be made to increase flying safety if world aviation is to retain people's confidence and not lose all the ground it has striven so hard for in the last year or so. Notwithstanding the publicizing of infallible navigation systems, radar units and blind-landing methods, there is still today a dangerous gap. So-called blind-landing systems do effectively succeed in bringing an aircraft home to a point very near the runway, and this with almost one hundred percent security, but fade out when it comes to the most important section of the approach, the actual landing to touch-down.

It is not without purpose that, in the construction of large airports, the various States attach great value to the perfection and completeness of the ground equipment in their efforts to reduce hazards in bad-weather and night operations. Undoubtedly one of the most important items of this equipment is the lighting system, and here the technician finds a field which has an abundance of promising possibilities for improvement.

The basic aim in designing an airport lighting system is to provide the crew of incoming aircraft with the elements for defining altitude, flying attitude, direction and speed, such as are available in broad daylight. As long as the existing automatic navigation and landing systems are not able to bring an aircraft down to touching the runway, pilots have to be provided with conditions permitting them to complete the procedure by visual reference, without radio or other instruments.

Certainly in no other field of aeronautics does such anarchy prevail as in that of airport lighting. Already before the war, every air force had its own scheme which, besides, could reveal still further differences according to the responsible commandant, and seldom coincided with the system stipulated by the national civil aviation authority. Improvements were immediately cloaked with secrecy and, in general, the method of lighting up the airport was the pet hobby of the officer in charge, provided he was at all interested in it. It was not until the war, bringing with it unlimited cash resources and greater demands on ground organisation in view of the restrictions the weather and bad light conditions imposed on combat operations, that airport lighting was subjected to new technical demands. These conditions prevailed strongly in Great Britain, where not only British air units were stationed, but U. S. forces too. There was an occasion to compare under service conditions the finally standardised British lighting system with those introduced by the United States and in operation at AAF bases.

The system in operation at London Airport incorporates the best features of the British and American schemes. The lights used were developed in America, and represent a big step towards providing a simple and reliable lighting system. Designed by *Bartow Beacons, Inc.*, and sold under the trade name of *Bartow High Intensity Lighting Units* (Fig. 2), they give the pilot all the data he needs for defining his flying attitude in relation to the runways, this, of course, provided that they are set up correctly.

As, therefore, the lighting system has not only to make the airport and runway visible, and to indicate the presence of obstacles, but must also serve as horizon for an oncoming pilot, the lights may not be set out in just any arrangement. In daylight a pilot goes through the landing procedure more or less by intuition, without giving much thought to any particular optical elements he might be using to judge his flying attitude. The entirety of the various points of identity gives him a perspective picture of the airfield and its vicinity, from which he is able to judge his altitude, attitude, distance from the runway, direction, speed, etc. When bad visibility or night sets in, a few or perhaps all of these points of identity are removed, so that they must be supplemented or entirely replaced.

The point-sources of light must be distributed so as not to allow for optical illusion or ambiguity of interpretation. For this reason, the approach lane and runway should be represented by two parallel and horizontally-placed rows of lights. As an aircraft

Fig. 2 : Bartow High Intensity Lighting Unit.

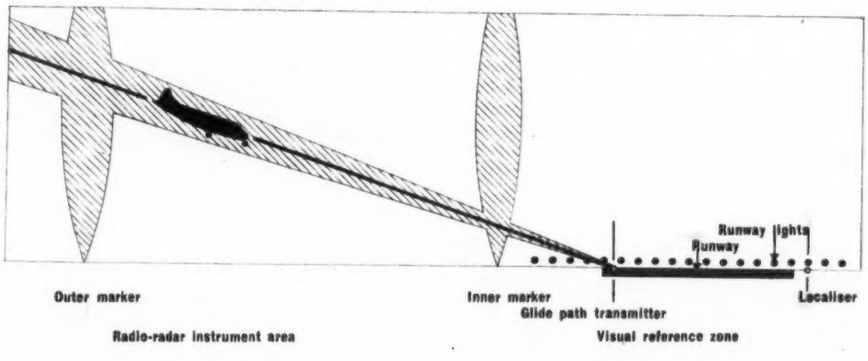
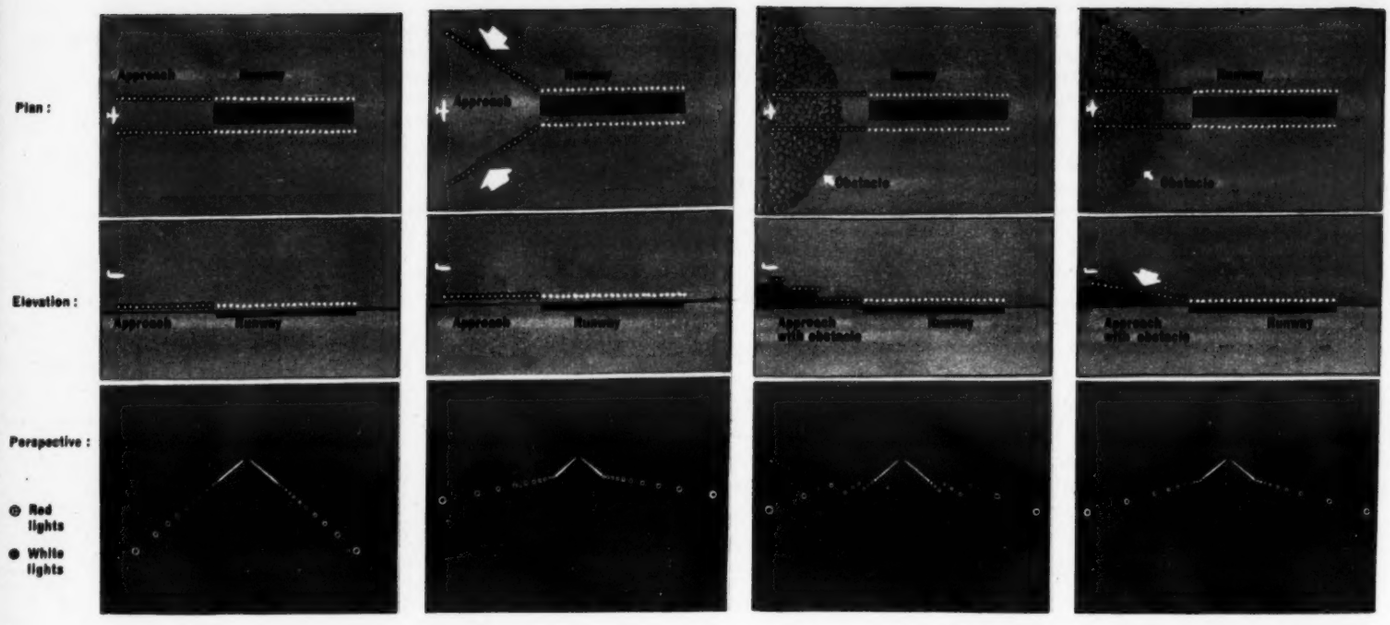


Fig. 1 : Schematic representation of a landing ; the area on the left is governed by the instrument aids, whereas the area on the right (visual reference) is dependent on the airport lighting system.



Good... Lights on same level and parallel ; true perspective.

Bad... Needless fanning out of approach lights ; yields false perspective and possible false judgement of attitude.

Good... Stair-stepping approach lights down over obstacle, but parallel ; true perspective.

Bad... Creates optical illusion and false perspective ; difficult to judge altitude and attitude.

Fig. 5 : Comparison between the right and wrong ways of placing approach and runway lighting units.

nears the airport the pilot should, if he is approaching correctly, obtain a view as represented in Fig. 3. As he loses altitude, the apparent angle between the light rows closes. If one wing is low, the arrangement of the rows rotates, so that the pilot may re-adjust his aircraft accordingly, as if he had an artificial horizon before him. Fig. 4 shows these conditions in an approach with the left wing high. Covering up one half of Figs. 3 and 4, provides a simple test to show that one single row of lights does not enable a pilot to judge attitude.

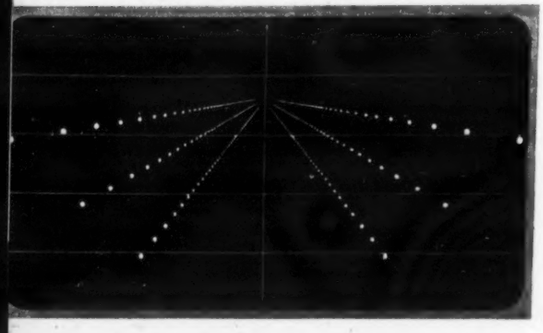


Fig. 3 : Impression given by the two rows of lights to an aircraft losing altitude and approaching correctly.

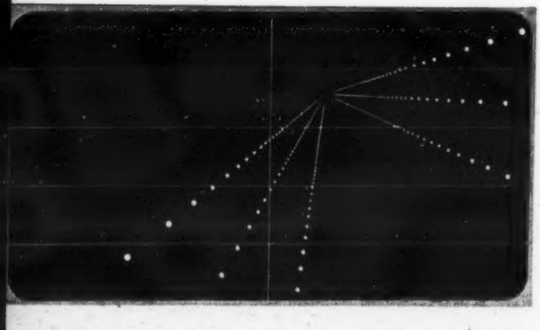


Fig. 4 : Same as in Fig. 3, but with the right wing low.

As already stated, the lights must be on a level and parallel. For instance, if the contact and approach lights are converged on the runway at an angle, a false perspective is created, making it impossible for the pilot to determine the altitude and attitude of his aircraft. A similar illusion is created when the approach lights are sloped down over obstacles. In order to overcome these, a stair-stepping arrangement down over the obstacles must be provided. Fig. 5 presents a series of drawings to illustrate these conditions.

In order that the lighting system may be effective under conditions of fog, bad visibility, etc., the lights must be of variable and very high intensity. But intense light sources are coupled with glare effects, and undesirable halo can be caused in foggy weather. In order to obviate these interferences, the Bartow lights do not incorporate the usual spherical distribution of rays, but *accurate beam control*, as is shown in Figs. 6 and 7. In this way, not only is glare obviated, but also halo, which is caused by the reflections from suspended particles (snow, fog, etc.) of angular rays that

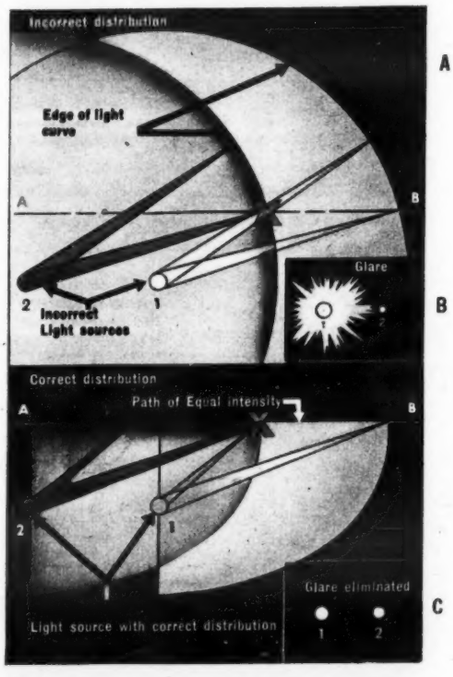
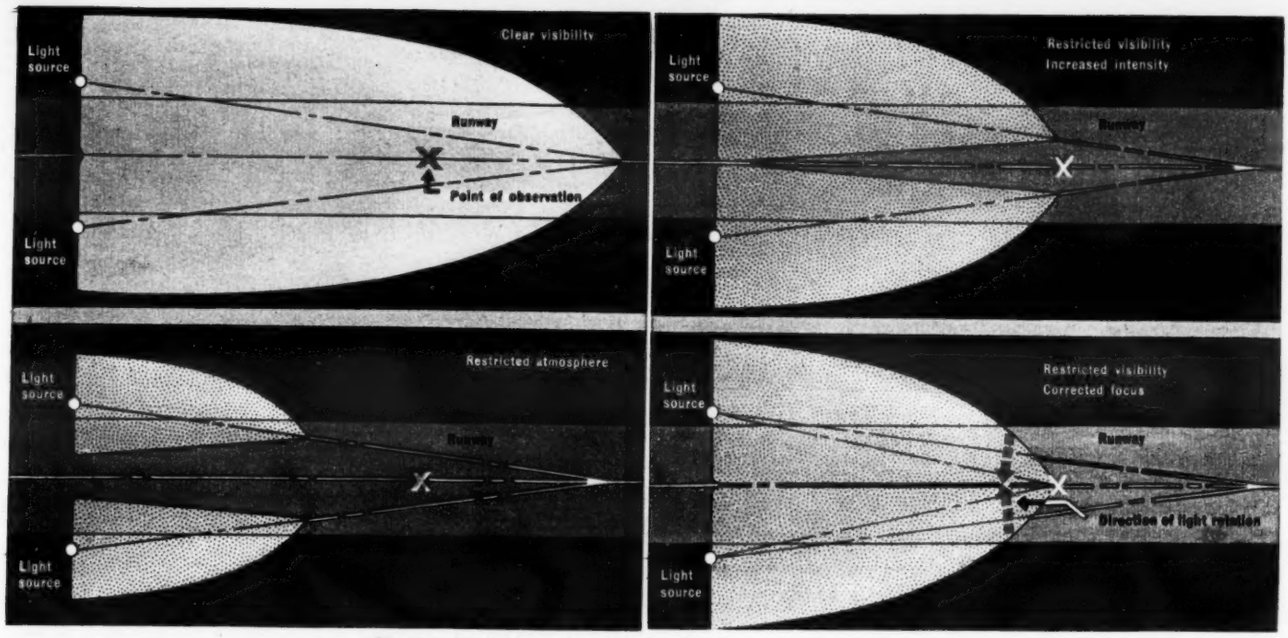


Fig. 6 :

A. Spherical distribution from lights 1 and 2. From point B, light 1 is just visible ; light 2 should be visible from point X, but is greatly disturbed by the glare from light 1.

B. Glare from light 1 considerably reduces visibility of light 2.

C. Glare eliminated by introduction of *controlled distribution*. Both lighted areas now extend to line A-B. Equal intensity seen from point X.



Figs. 8 to 11 : Influence of varying light intensity of the Bartow system.

would not be visible in clear atmosphere. However, there is more to it that just eliminating glare and halo : uniform intensity of airport lighting must prevail, no matter what atmosphere. Fig. 8 shows the light distribution

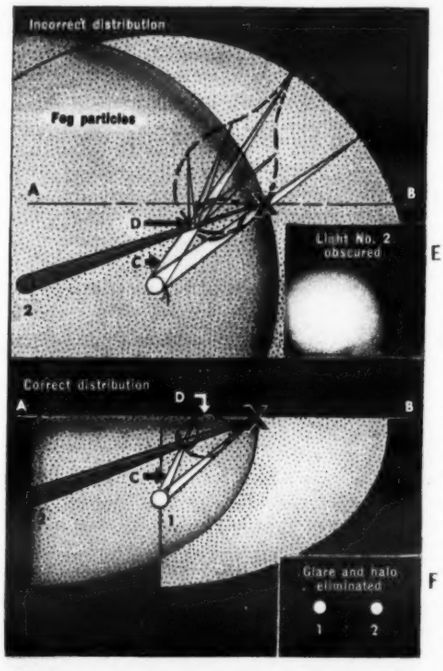


Fig. 7 :
If an observer moves along A-B to X, he will not be able to see light 2 from X ; beam C from light 1 is so strong that it is reflected from droplet D, resulting in a halo.
E. Light 2 is invisible to the observer. Distribution reaches line A-B. With controlled distribution, the angular beam C is no longer strong enough to reflect from particles.
F. Lights 1 and 2 are both visible. Glare and halo are eliminated.

by two sources, as it would appear under normal visibility conditions. If the beam intensity is not changed to suit subsequent bad weather, the light envelope will shrink (Fig. 9) and a part of the runway will not be illuminated. This can be rectified by increasing the output of the lamps, but a path of equal brightness will all the same not be restored (Fig. 10). However, by re-focusing and rotating the axis of the two maximum candlepower beams so that they again intersect along the centre line of the runway (Fig. 11), the dark area is eliminated and the path of equal brightness restored.

It will be realised, therefore, that a pilot coming in to an airport fitted out with the Bartow system will see progressively more and more units as the touch-down is neared, thus continually increasing the impression of perspective.

A further important feature of the Bartow lamps is their ability to provide angular control of the intensity, so that the nearest unit appears just as bright to the pilot as the farthest one, wherever his aircraft may be. This avoids strain on the pilot's eyes by the glare from near-situated units, which could make it difficult for him to spot the lamps located further away. In addition, angular control minimises the danger of glare and halo even in extremely high candlepower beams.

The Bartow High Intensity Units, standing about 18 in. high in their sockets, are placed along the runway edges. They are designed to break off at the base if struck by a taxying aircraft, so that only negligible damage results. In this connection U. S. Navy statistics show that the number of such mishaps decreases as the runways are widened : on a 200-ft runway, one collision in 12,855 landings and take-offs ; on a 300-ft runway, one collision in 17,180 landings and take-offs. Different coloured filters may easily be inserted inside the detachable glass top ; there is usually a red filter on the side facing the approach direction, so that the danger of an incorrect approach is practically eliminated, despite the disconcerting multiplicity of lights.

There is no doubt that the international adoption of standard lighting equipment for airports will cut the accident rate down appreciably. The various national air authorities are taking the matter very seriously and subjecting all available types of lighting system to thorough tests, this also in order to eliminate the makeshift systems used on wartime air bases and to clarify the existing confusion. At the AAF Landing Aids Experiment Station, Arcata, California, in bad weather with visibility limited to 150 - 200 ft., CAA established a visibility range for Bartow lamps of 800 - 1,200 ft. These figures probably indicate minimum values, and it can be taken for granted that in time these ranges will be stepped up to such an extent that civil aviation will have a new, simple and reliable approach lighting system, providing a happy link with the electronic landing aids.

Kelly Field, near San Antonio, in Texas, a training station, one of the biggest and most modern AAF bases.

The A.A.F. does all right

Fairfield-Suisun, the big new Air Transport Command base in California, welcomes its passengers : 8,046 miles to Tokyo in 39 hours 10 minutes, 2,479 miles to Washington in 12 hours.

The car stops. You find yourself in the centre of a little town and look around. Groups of small houses, green lawns, gay flower beds, a plate with the occupant's name in the grass between the trees near the front doors. Broad avenues, narrower streets, the usual traffic signs, wide side-walks, pedestrians... a typical American small-town but for the absence of the corner drug-store and dress of the inhabitants.

The latter wear khaki, for they are members of the U. S. Army Air Forces. They are the men and women who run the permanent air bases which are the backbone of America's peace-time Air Force. The bases are not very great in number, but their importance is considerable. They constitute the headquarters of the individual Air Forces composing the A. A. F., and it is around them that the present structure of Air Reserve and Air National Guard is built—units which in emergencies must be ready to expand and take over the numerous satellite bases at a moment's notice. Bases are also needed to operate the training programmes and to keep the " Army's Airline ", the Air Transport Command, in the air.

Bases have to be built where space is available. Hence they are often somewhat " in the sticks ", miles away from anywhere. Famous Mitchell Field, headquarters of the nation-wide Air Defence Command, is in a more favourable position in this respect than many others : it is surrounded by villages, yet it is a long way from New York. Kelly and Randolph Fields, the huge Texan training centres, are miles from San Antonio ; Fairfield-Suisun in California is situated in the Sacramento Valley six miles from the twin villages of Fairfield and Suisun ; Hamilton Field is a long bus ride from San Raffael and an hour's drive from San Francisco. March Field is located in the Californian desert some distance outside the lovely little town of Riverside and sixty miles from Los Angeles.

As a result of this isolation, the Army's permanent air bases are practically self-contained communities. The inhabitants, between three and four thousand at each base, enjoy all the facilities a small town can offer, with the difference that owing to the absence of " private enterprise " these are neither duplicated nor competitive. What is more, the " townspeople " get their goods at prices from 30 to 60 percent below normal commercial prices.

Take the commissary, for instance : the wives of Air Force officers and enlisted men buy all their " crispy, crunchy, body-building " corn flakes, wheaties and rice krispies for half the usual shop price, " built-in goodness " included, as well as all their canned goods, their eggs, fruit, vegetables and the rest of their staple foods. Only specialities have to be obtained outside. From the commissary we move to the " PX ", short for Post-Exchange. At the PX you buy your Army uniforms, if you happen to be an officer, at an extremely low price. Apart from that you can get practically anything a medium department store has to sell, short of grand pianos. But if you want a fountain pen, or jewelry, or a tooth brush for the girl friend to prevent her from using your own, go to the PX and spend half your money. Attached to the PX is usually the post cafeteria where the G. I.'s have dinner if they miss the regular mess meal, and next to it a soda fountain, normally packed with soldiers sipping malted milk shakes and similar American concoctions, whilst pin-up girls in dresses leaving little to the imagination smile their toothy smiles from the walls.

When the Army Air Forces and its predecessor, the Army Air Corps, built their bases, their architects proved that " military establishments " and " ugliness " need not be synonymous. They succeeded in blending the bases structurally with their natural surroundings, and wherever possible they adopted local styles of architecture. In California, for example, the headquarters' buildings, officers' clubs, enlisted men's mess halls and barracks are generally built in " militarised " Spanish-Mexican hacienda-style, which tends to humanise military routine.

Social activity at an air base centres around the officers' club, which always includes a very dignified bar serving only weak beer (but every officer has his own hard-liquor bottle, duly labelled with his name, on a shelf), a restaurant, and even more dignified and stylish lounges, as well as a ballroom — but just go around the corner and you are bound to find a group of uniformed youngsters zealously pushing dimes and quarters down rows of slot machines in the forlorn hope of hitting the jackpot. At Hamilton Field, for example, the net profit accruing to the club from the slot machines averages about $ 5,000 a month... And after you have lost more money than you figured on winning, you decide to spend a cheap evening and go to the camp cinema, always a modern affair, which costs you nothing.

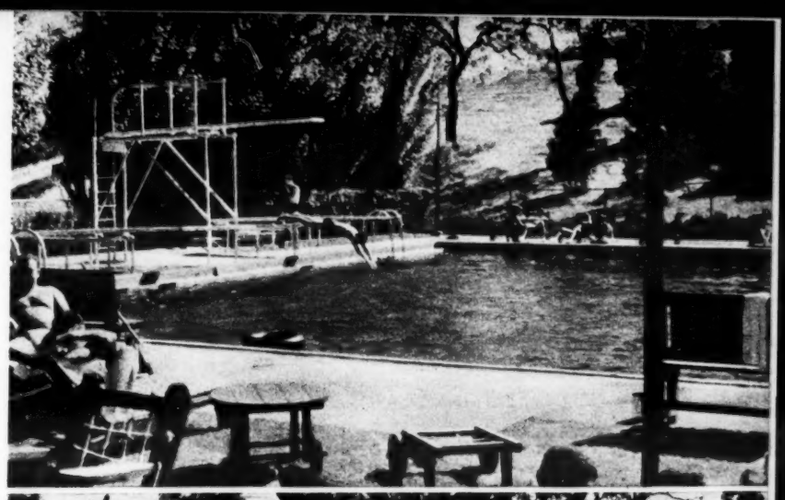
If you like more vigorous amusements than cinema and slot machines, you will no doubt gravitate towards the gymnasium or the inevitable ball park or baseball diamond, either as a spectator or as an active participant. And once you've worked yourself into a state of profuse perspiration, by shouting yourself hoarse or by playing the game, you take a dip in the swimming pool. Normally, there are two pools, one for officers and their wives and W. A. C.'s, another for enlisted men. If coloured men are on the base, they are allocated one or two " swimming days " weekly. We watched them diving into their pool in gay abandon, and as we were more than ten yards away, we liked to believe that they were all wearing black bathing trunks.

Living accommodation at the permanent air bases is more comfortable and spacious than most civilians dare expect in these days of housing shortage. Married officers are quartered in pleasant furnished houses and enjoy the utmost privacy ; unmarried officers live at BOQ — Bachelor Officers Quarters — in well-appointed rooms, complete with bath or shower. Married enlisted men and N. C. O.'s are also accommodated in small houses, perhaps more tightly spaced than those of officers, unmarried N. C. O.'s are given separate rooms, enlisted men live in dormitories with all the latest comforts and spend their free time in spacious recreation rooms.

Don't get the impression that American Army Air Bases are a case of " all play and no work making Jack a dull boy ". Uncle Sam sees to it that his airmen are well cared for, but, being an American, he wants something in return for his money. Officers and men

The cinema is easy on your pocket-book. The latest movies cost you nothing.

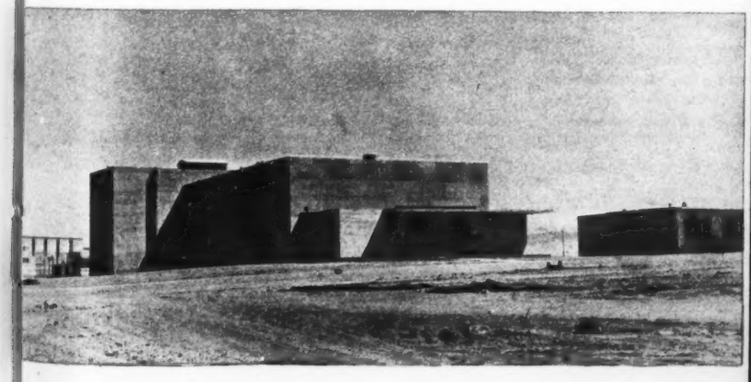
If you feel hot, take a dip. The officers' swimming pool at Hamilton Field, California. ▶

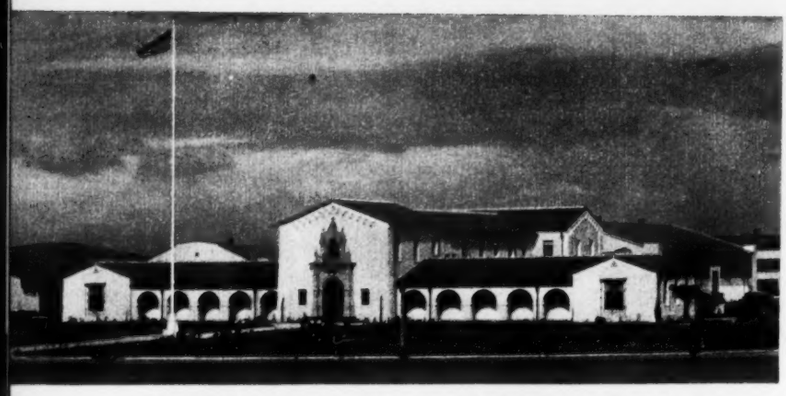


The Officers' Club at Hamilton Field. For the slot-machines, turn left after entering, walk right through and then turn right. ▶

The lounge of the Officers' Club at March Field, Cal. Comfy? ▶

Right, above:
One of the dormitories for enlisted men at March Field. Snoring prohibited.





The Spanish-Mexican style of the headquarters building at Hamilton Field takes some of the austerity out of the air base.

Built into the natural beauty of oak trees and rolling hills, permanent quarters for officers and their families are comfortably spaced on the edge of Hamilton Field.

A vast workshop in one of the hangars at March Field. Practically all aircraft and engine repairs are carried out on the spot.

◀

▶

The General lives near here. Married officers' quarters at March Field.

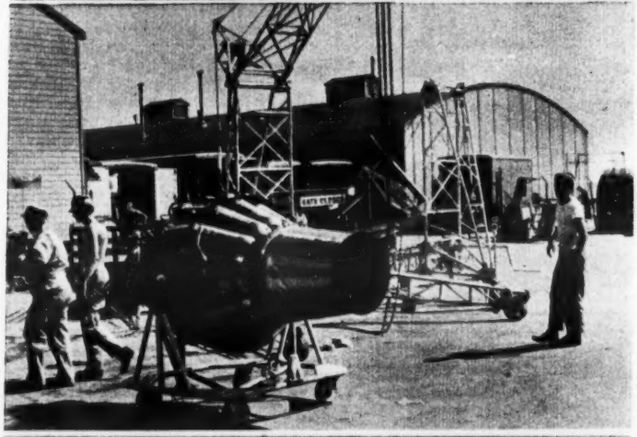
◀

Beauty treatment for a Fairchild C-82 "Packet" transport in the hangar at Hamilton Field.

follow a strict daily routine of flying, instruction, training, maintenance work, operational planning, etc., for the permanent bases of the U. S. A. A. F. are largely responsible for the operational testing of new aircraft, radar equipment, tactics and so on. Should war come again, they will form the well-trained modern nucleus of the bigger Air Force that will be built around them.

The A. A. F. is keeping in close touch with the American public, and each base has its own efficient Public Relations Office. Local papers are eager to report on the activities of these stations, and the bases are eager to supply the local press with all the "dope" it wants. When we arrived at Hamilton Field last summer, we found the Security Officer, Colonel Pope, an otherwise very energetic personality, sitting on the floor of his office on a huge map of the base, directing his men to post guards here and there and everywhere. For on the following day 50,000 "shriners" (a species of free-mason), who were holding a convention in San Francisco, were coming down to inspect the base, and the Colonel wasn't taking any chances. We understood his feelings and, being more mobile, in turn decided to remove ourselves to a safer place before the invasion.

PAB.



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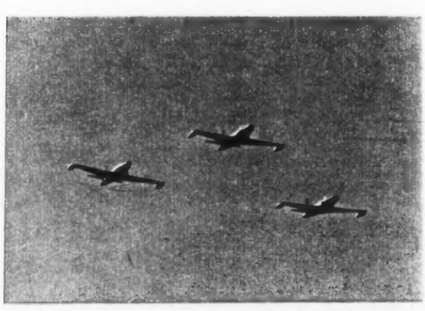
The power plant of a "Shooting Star" is overhauled under the Californian sun. "Let's get a Coca-Cola, bud . . ."



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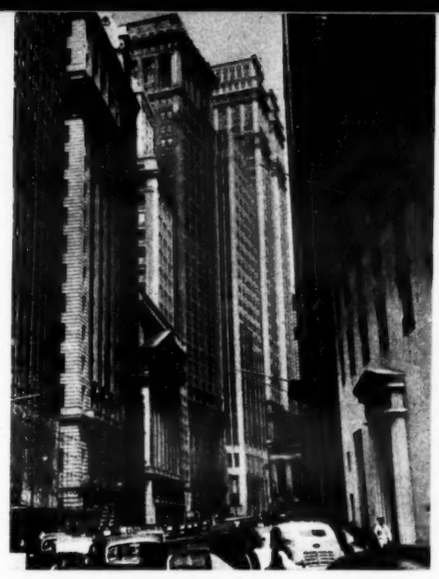
Formation flying training: Lockheed "Shooting Star" jet fighters from March Field pay a visit to the Long Beach air base, eighty miles away.

On the flight line at Hamilton Field: North American "Mitchell" bombers getting ready for a routine flight.

◀

Economic Aspects of the American Aviation Industry



(III)

The success or failure of an individual air line's financial management, particularly the timing with which stock is sold for additional capital, has had important effects on the overall competitive position of the individual air lines and even more important effects on the long term welfare of air line security investors. The air lines are strictly regulated and the regulatory authorities, in their power to set mail pay rates and to control passenger and cargo rates, have been able to determine what percent return may be earned on capital investment. The Civil Aeronautics Board, in previous decisions, has allowed a return on invested capital of between 8 % to 10 %, with efficient management, and under the Civil Aeronautics Act of 1938, the scheduled air lines are theoretically assured of sufficient financial support, through mail compensation, to maintain and continue the development of air transportation. Since the stock prices of the five largest air lines have swung widely in recent years, with an average high of 3.5 times book value at the top in 1945 and a recent low of 1.1 times book value, it is obvious that careful timing of financing has been most important. The sale of additional stock for new money purposes at a time when the stock is selling substantially above book values has the effect of adding book value to all the outstanding shares, while the necessity because of financial stringency, to sell stock below book values, has the effect of diluting the book value of the presently outstanding shares and thereby theoretically reducing permitted earning power of the air line system.

Recent air line financings are therefore of more than casual interest to students of air line economics. The United Air Lines program to raise $ 49,500,000 new money, recently completed, was successful in view of the market conditions. The funds were secured by sale of $ 12 million 3½ % debentures, a $ 28 million term loan from a group of more than 30 banks and an offering of 94,773 shares of $ 100 par cumulative preferred stock with a coupon rate of 4½ %, convertible into 4 shares of common, to present stock dealers. The dilution through conversion of the preferred stock into common stock will be only about 20 %.

In comparison, the financial difficulties of Transcontinental & Western Air, Inc., have not been solved on any financially satisfactory basis. To tide over the Company, the Hughes Tool Company purchased on February 3rd, $ 5 million of 3-year convertible notes and has committed to purchase an additional $ 5 million of such notes before June 1st of this year. These notes are convertible into common stock at a price to be determined, and forecast an equity financing at a later date. TWA is reported to be continuing negotiations with the Reconstruction Finance Corporation for a $ 40 million loan, but the recent resignation of TWA President Jack Frye and other senior executives complicates the financial program. It is reported that Howard Hughes, now solidly in control with 13 new hand-picked directors on the Board, is in favor of abandoning foreign operations in an effort to get the line in the black. (Editor's note : This is now denied by the Chairman of TWA's new Executive Committee, A. V. Leslie, as having " no basis in fact and being contrary to the management's opinion ".)

One of the most important statements in recent months regarding the Government's attitude toward air line problems was made by James M. Landis, Chairman of the Civil Aeronautics Board, in a radio speech in the middle of February. He said that one of the solutions for the air line problems will be the working out of consolidations of certain carriers, particularly the weaker ones. This is a substantial reversal of the earlier attitude of the Board toward consolidation of air lines. It is questionable, however, whether there is much prospect of air line mergers in the immediate future. An upturn in air line earnings and a return of investment confidence is needed first.

Mr. Paul F. Collins, President of Northeast Airlines, recently said that the possibility of a merger with Pennsylvania-Central Airlines does not appear bright. He disclosed that, as of January 1st, Northeast had current liabilities of $ 1,116,000 and cash available for payment of these debts of only $ 103,000. He told the examiner that the Company must have $ 1,121,000 by April 30th in order to stay in business, and that increased mail rates and passenger rates are essential.

While the financial crisis has become acute for some of the smaller and less financially solid air lines, opinion in the industry that a turning point in traffic and earnings is in prospect this spring, has been gaining support. Mr. C. Bedell Monroe, President of Pennsylvania-Central Airlines, predicted that 1947 will see a gain of at least 26 % in air line traffic over the record volume of 1946. (See table on P. 56.) Blaming most of the problems of the air lines on the untimely fare reductions of a year ago, he stressed that if early relief can be obtained through the granting of increased mail pay and more equitable fares, it would pave the way for operating profits as soon as new equipment is made available. Otherwise, he emphasized, many carriers are going to face a crisis.

The following table shows the development of traffic and revenues for domestic air lines in selected years. A gain of 26 %, as predicted by Mr. Monroe, would be more than satisfactory on top of the gains last year and in earlier years.

Domestic Airlines

Revenue Ton-Mile Handled

Yr. Ended June 30	Passengers *	Mail	Express	Excess Baggage	Total	Operating Revenues	Operating Profit
	(in million ton-miles)					(millions)	
1935	22.2	3.4	0.8	0.2	26.6	$ 22.9	$ d 3.3
1937	40.5	6.4	2.1	0.5	49.5	37.1	d 0.3
1939	55.0	7.9	2.4	0.5	65.8	47.3	1.0
1941	118.7	11.2	4.2	1.1	135.2	84.7	3.7
1943	142.6	28.4	14.3	2.8	188.1	113.3	30.5
1945	283.0	61.7	22.6	4.5	371.8	193.2	44.5
1946	456.2	50.3	23.7	4.8	535.0	254.8	14.6
month of Nov., 1946	—	—	—	—	—	24.4	d 3.0

* Each passenger with baggage assumed to weigh 200 lbs.
d = Deficit.

The most important development in the aircraft manufacturing industry during recent months has been the argument over the Federal budget as it affects military purchases of new aircraft. The aircraft appropriations bill for the fiscal year ending June 30th, 1947, included approximately $ 402 million for Army Air Forces procurement and $ 310 million for the Naval Bureau of Aeronautics aircraft. This total of $ 712 million is more than three times that for the largest peacetime year. In addition, $ 184 million were provided for Army Air Forces research and $ 100 million for Navy research, aggregating $ 996 million for aircraft expenditures. For the fiscal year ended June, 1948, the Presidential budget recommendations include $ 850 million for the Army Air Forces and $ 536 million for the Navy Air Forces, a total of $ 1,386 million. However, with Republican control of Congress and with the Republicans on record as favoring up to a 20 % cut in the overall budget, there appears to be no assurance that these funds will be appropriated. If, however, the requests for Army and Navy aircraft appropriations of $ 1,386,000,000 were cut down by 20 %, it would still involve an expenditure of over $ 1,100,000,000, or substantially above the preceding year. The level of development activity provided in the requested budget figures would be substantially higher than in any preceding peacetime year and would include a very wide range of research activity.

Toward the end of February, President Truman sent Congress legislation to unify the Army, Navy and Air Forces under a single Secretary of National Defense. Adoption of this program is tantamount to a promise of far reaching changes in the long term development of the aviation industry. The Army Air Force top officers include, and perhaps are dominated by, a group of relatively young men, frequently referred to in Army and aviation circles as the " Rocket Cowboys ". The basic belief of this group is that development work should be concentrated along jet and rocket lines, rather than to attempt to continue to increase the speed of reciprocating engine-powered and propeller-driven planes. Some of the Air Force enthusiasm for speed has in the past been overruled by Army men who believed in a feet-on-the-ground policy and discounted some of the more spectacular ideas of the Air Force men as impractical. When the Air Force emerges as a separate division on an equal with the Army and the Navy, it seems probable that some of the development plans for advanced types of aircraft and some of the longer range research programs in aeronautics may be pushed ahead more vigorously.

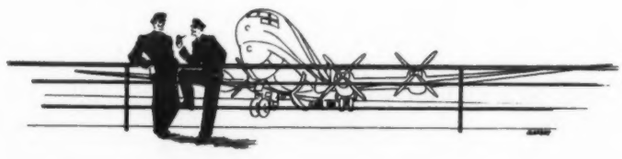
Leading air line and aircraft executives seem to agree that the reciprocating-engined, propeller-driven type transport will not be replaced to any large extent on the air lines for five years or more, but that Air Force development work, assuming present trends continue, will be more heavily weighted toward the rocket and jet planes year by year. This may mean a considerable cleavage in the aviation manufacturing industry, with one group of companies concentrating on relatively conventional type craft for the air transport field and another group concentrating on radical high-speed aircraft for the Air Forces. The primary companies in the radical type craft for the Air Force would appear to be Bell, Northrop, Republic, Grumman, North American and Ryan. The conventional type craft will probably be produced by Beech, Boeing, Consolidated Vultee, Douglas, Lockheed and Martin. Several of these are also doing development work for the Air Forces. The engine builders, including Curtiss Wright, United Aircraft and Fairchild, are all developing from the conventional reciprocating engine field into the more radical type jet and rocket engines, but several newcomers seem to be involved in the most interesting projects, with General Electric, General Motors and Westinghouse among the larger companies, and Reaction Motors among the smaller companies, doing a considerable part of the work.

The announcement of cancellation of the American Air Lines order for 20 Republic " Rainbows " came as no surprise in financial circles. No announcement on the six " Rainbows " on order by Pan American Airways has yet been made, but it is considered as certain in the industry that Republic will not proceed with the production of such a small number of planes and that this order also will be cancelled by mutual agreement. It became increasingly clear that only five important companies have any substantial position in the air transport field. Out ahead is the Douglas Aircraft Company, with orders approaching 200 DC-6's. Companies at present with a position in the transport field are Consolidated Vultee, Martin, Lockheed and Boeing. Of the latter, Consolidated Vultee, with orders on hand for 150 units of its new Model 240 twin-engined transport, seems to have made the best relative gain in this field since before the war. The Company says it has about $ 328 million of backlog including military business, this exclusive of non-aircraft products. A net loss of $ 2,776,000 was reported for last year, but with development expense substantially reduced, prospects for 1947 are more encouraging.

Air line and aircraft manufacturing stocks showed no significant change during January and February, moving generally with the market in a relatively narrow range. The success of United Air Lines' financing, and reports of early rate increases did, however, give a better tone to the air line group towards the end of February.

March 1st, 1947.

Baker, Weeks & Harden.
Wall Street
(Jeremy C. Jenks).



THE MONTH IN REVIEW

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POLITICAL

● The *Italian Defence Minister*, Luigi Gasparotto, has appointed a Committee to unify and co-ordinate the three Services.

● The Cabinet of France's Air Minister, André Maroselli, has finally been organised as follows : Chief of Cabinet, Matteo Connett, with Jacques Maroselli as his Deputy ; Chief of the Civil Cabinet, Robert Pierson ; Technical Adviser, Paul Gorez.

● On February 25th a *French Government spokesman protested* against the move of the Indian Foreign Minister, Pandit Nehru, to limit the number of French aircraft crossing India on their way to Indo-China. This policy, dictated by India's sympathy for the Indo-Chinese Nationalists, may effect future Franco-Indian diplomatic relations.

● The Council of Deputy Foreign Ministers in London has drafted a plan for the future *armed forces of Austria ;* the Air Force will be limited to 5,000 men and 90 aircraft, including up to 70 % combat aircraft but no bombers.

● The Civil Aviation Council of the *Arab League*, which is at present examining a *Civil Aviation Agreement* between Member States, has agreed that each Member State shall possess air sovereignty rights.

● *Bilateral Civil Aviation Agreements* have been concluded between the following countries : Portugal-Sweden ; Spain-Argentina (March 1st) ; Great Britain-Greece (February 24th). Negotiations for agreements are taking place between Great Britain and Finland ; Australia and the Dutch East Indies ; Argentina and France ; Argentina and Portugal ; and Argentina and Bolivia. Sweden and France are negotiating for modifications of the existing agreement between the two countries.

NEW AIRCRAFT

● On February 10th, the prototype *Dessault D 303* " Guyenne " twin-engined multi-purpose aircraft built by Avions Marcel Dessault (formerly Avions Marcel Bloch) underwent its first test flight. Colonel Rozanoff, the firm's Director of Flight Tests, was amongst those on board.

Bellanca 14-13 " Cruisair Senior ".

● Bellanca Aircraft Corp. is developing a new version of its prewar Bellanca 14-9, a new four-seater personal aircraft designated the *Bellanca 14-13 " Cruisair Senior "*, with a 150-H.P. air-cooled Franklin flat-six. It is fitted with dual controls, retractable undercarriage, and wing flaps ; and will be delivered with standard flying instruments, electric starter and hydraulic wheel brakes. Gross weight, 2,100 lbs. ; max. speed at sea level, 169 m.p.h.

Martin XP4M-1.

● Northrop Aircraft Inc. is collaborating with the USAAF on the development work for supersonic experimental aircraft ; it has been entrusted with the design of an experimental supersonic aircraft, the *Northrop XS-4*.

Wind-tunnel model of Curtiss-Wright XA-43.

● The *Curtiss-Wright XA-43* four-engined jet attack bomber (with a three-man crew) is powered by four General Electric J-35 gas-turbine engines each of 4,000 lbs. thrust ; the engines are mounted in pairs in two large engine nacelles.

De Havilland " Vampire II ".

● A new version of the De Havilland DH 100 " Vampire " is designated *De Havilland " Vampire II "*, If differs from its predecessor principally in its power plant, which is a Rolls-Royce " Nene " gas-turbine of 5,000 lbs. thrust instead of a De Havilland " Goblin ". The new version is to be produced in considerable numbers by English Electric Co.

● The first prototype of *Glenn L. Martin's XP4M-1* four-engined patrol bomber is at present undergoing test flights. It is one of the most completely equipped aircraft as regards radio, radar and navigational instruments. Power is provided by two 3,000-H.P. Pratt & Whitney " Wasp Major " radials and two Allison gas-turbine engines of 4,000 lbs. thrust.

● The Italian aircraft designer, Campini, well known as the creator of the first Italian jet-propelled aircraft, the Caproni-Campini, is developing a *roadable helicopter*. It would appear that the aircraft has a jet-propelled rotor with folding rotor blades. Speed, 112-124 m.p.h. ; max. road speed, 55 m.p.h.

INDUSTRY

● Republic Aviation Corp. and American Airlines Inc. issued a joint statement on February 21st announcing that their *contract for 20 Republic " Rainbow "* four-engined high-speed transport aircraft had been *terminated* by mutual agreement. The cancellation is believed to be due to technical difficulties, encountered particularly with the cabin pressure equipment which was to give the aircraft an operational altitude of 40,000 ft. Though this is not stated, Republic may not go ahead with the production of the " Rainbows " ordered by other companies.

● *Willys-Overland Motors, Inc.* is conducting supersonic research for the design and development of new weapons for the U. S. Navy Bureau of Aeronautics. The firm also contemplates developing military aircraft types.

● G & A Aircraft Inc., manufacturers of gyroplanes and helicopters, and subsidiary of the Firestone Tire and Rubber Co., recently changed its name to *Firestone Aircraft Co.* President of Firestone Aircraft is Roger S. Firestone.

INDUSTRIAL PERSONALITIES

● L. G. Reid has relinquished his post as Managing Director of *General Aircraft Ltd.*, Feltham, Middx., and has resigned from the Board of its associated companies (Universal Flying Services Ltd., etc.), H. V. Gort has been made Principal Executive Director of General Aircraft Ltd.

* Abridged extracts from Nos. 1271-1278 (Feb. 18th to March 6th) of " INTERAVIA, International Correspondence on Aviation ", an illustrated newsletter published three times weekly in four separate language editions, English, French, Spanish and German.

● Cyril Frank Unwins, since 1919 Chief Test Pilot of The Bristol Aeroplane Co., Ltd., has been appointed Assistant Managing Director of the firm's aircraft division ; the new Chief Test Pilot is A. J. Pegg.

● Experimental Factory No. 300 of the Soviet Ministry of Aviation Industry, and its Chief Designer and Director, A. A. Mikulin, have both been awarded the *Order of Lenin* for outstanding services in the design of aero engines.

INTERNATIONAL ORGANISATIONS

● *PICAO :* Following the example of the U. S. A., the *Dominican Republic* and *Nicaragua* have announced their withdrawals from the International Air Transport Agreement (" Five Freedoms "). — The PICAO *Permanent Regional Secretariat for Europe and the Mediterranean* was recently opened in Paris (on the former ICAN premises — Avenue d'Iéna 60bis ; Telephone : Passy 37-34) and is headed by Lionel Bedin. — On February 20th the *Airworthiness Division* (AIR) held its second Annual Session at Montreal. K. T. Spencer (Great Britain) was elected Chairman, with Inspector-General P. J. Decros as his deputy. The currently topical question of weight limitations was amongst the subjects considered by the Division.

● *IATA :* The *European Regional Conference* of the International Air Transport Association decided at their meeting in Estoril, Portugal, on February 4th-8th, to extend the validity of present air fares to Europe beyond the established expiry date of February 28th. Another Regional Conference is to take place in Paris on March 11th to work out new fares for the summer schedules to be brought into force on April 20th. The *official IATA timetable* (schedules, fares, and main connections in the European air services operated by IATA members) is expected to appear in October and will be published jointly by the Librairie Chaix of Paris and Interavia S. A. of Geneva. — The technical *Sub-Committee for Airways Systems,* landing areas and ground aids placed on record in New York from February 18th to 21st that the airline companies were prepared at the present time to adopt the I. L. S. Instrument Landing System.

AIR TRANSPORTATION

● *North Atlantic : American Overseas Airlines* has been flying its daily New York-Shannon-London trans-Atlantic route without the previous intermediate landing at Gander since March 1st. — *Scandinavian Airlines System,* the Scandinavian joint carrier, is to intensify its North Atlantic services with a fifth weekly return flight ; Montreal and Chicago are to be the Western terminals instead of New York. — *British Overseas Airways Corp.* intends to increase its service from London to New York from four flights a week to one a day and will open a London-Montreal service. Since January 28th *KLM Royal Dutch Airlines* has reverted to the New York-Gander-Amsterdam route for eastbound flights but is still flying via the Amsterdam-Santa Maria (Azores)—Sydney (Nova Scotia)—New York route on its Amsterdam-New York and Amsterdam-New York-Curaçao services. — *Swissair* is planning a special Geneva-New York mail flight for May 2nd with a DC-4.

● *South Atlantic :* The recently concluded *Swedish-Portuguese Civil Aviation Agreement* gives Scandinavian Airlines System landing rights on Sal Island (Cape Verde Islands).

● The U. S. Civil Aeronautics Board announced that " a review of recent aircraft accidents indicates the need for *additional operational requirements for non-scheduled air carriers* to be made effective without delay ".

● The U. S. Civil Aeronautics Administration has recommended the adoption of the 1947 *National Airport Plan.* A total of 4,423 airports are to be improved or built at a cost of some $ 985,800,000, with a Federal Government participation of $ 441,600,000, and $ 544,200,000 contributed by State and Municipal authorities.

● Senator Patrick McCarran, Democrat, and father of the U. S. Civil Aeronautics Act of 1938, called for the fourth time for the *establishment of a single " chosen instrument " company* for the operation of all American overseas commercial air services.

● *American Airlines Inc.* flew 6,238,966 ton-miles of air freight in 1946, an increase of 221 % over 1945, whilst air mail figures showed a 45.7 % decrease.

● *Braniff Airways Inc.* has received a loan of $ 10,000,000 from a group of eastern banks for the purchase of new flying equipment.

● The differences of opinion in the management of *Trans World Airline* ended on February 21st with the resignation of the President and Founder of the Company, Jack Frye. E. Lee Talman, Senior Vice-President, and General T. V. Wilson, Chairman of the Board, have also resigned. A new Executive Committee formed by Howard Hughes, the airline's principal shareholder, with A. V. Leslie, a banker, as Chairman, is endeavouring to obtain a $ 40,000,000 loan from the Government-controlled Reconstruction Finance Corp.

● The *USAAF has offered 20 GCA sets* for temporary use by civil airlines on a loan basis.

● *KLM Royal Dutch Airlines* proposes to engage a number of former transport and bomber pilots of the Royal Canadian Air Force with at least 1,000 flying hours.

● *British European Airways Corp.* is to have a stand at the Foire Internationale de Lyon from April 12th to 21st, 1947.

● The Government-controlled *Ceskoslovenske Aerolinie,* which officially started operations in March, 1946, but owing to lack of flying equipment was unable to inaugurate major scheduled services before July, flew a total of 1,070,000 aircraft miles up to the end of the year, carrying 58,500 passengers. On March 1st, better working conditions were brought into force for the airlines' air crew personnel.

● Group Captain Saward of B. E. A. C., Engineer P. Senn of the Federal Air Office, and Dr. von Meiss, Technical Director of Swissair, held discussions in Zurich concerning the introduction of the Gee radar navigational system in Switzerland.

AIRLINE PERSONALITIES

● *KLM Royal Dutch Airlines* has appointed its Secretary, L. H. Slotemaker, as Assistant Managing-Director in charge of foreign relations. He is succeeded as Secretary by J. van der Wiel.

● D. N. Gupta, previously Calcutta Regional Aerodrome Officer, has been appointed *Indian Representative to PICAO.*

● Group Captain A. E. Clouston, who made the first round flight between England and New Zealand, has been appointed *Controller of Civil Aviation in the New Zealand Air Department.*

SERVICE AVIATION

● *U. S. S. " Wright "*, a new American aircraft carrier, was officially commissioned on February 9th.

● The *U. S. Navy Air Missiles Testing Centre at Point Magu,* on the West Coast near Los Angeles, is to become a Permanent Guided Missiles Testing Range.

● The *Belgian Defence Budget Estimate* for 1947 provides Belg. frs. 444,296,000 for the Air Force (Belg. fr. 166,061,000 for current expenditure, and Belg. frs. 278,235,000 for maintenance and replacement of equipment). This estimate was unfavourably reported upon by the Defence Committee of the Chamber of Deputies, which considers the Air Force share in the total Defence Budget to be excessive.

MILITARY PERSONALITIES

● Sir William Barrowclough Brown, *Permanent Under-Secretary of State at the British Air Ministry* since October, 1945, died on February 11th, 1947, aged 53 ; he is succeeded by Sir James Barnes, previously Deputy Under-Secretary.

● Air Vice-Marshal Cyril Bertram Cooke, Director-General of Servicing and Maintenance, Air Ministry, 1946, has been appointed *Air-Officer-Commanding-in-Chief, RAF Maintenance Command.*

● On February 22nd, Lieutenant-Colonel Reixa, *Commandant of the Instrument Flying School of the Spanish Air Force,* was killed with the four-man crew in a Heinkel He 111 twin-engined trainer on the outskirts of San Sebastian.

● The German *Colonel-General Alexander von Löbr,* one-time Commander of the German Luftflotte IV in South-East Europe and later Commander of all German Forces in that area, was *sentenced to be shot* by a Yugoslav military tribunal.

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